CMOS SCMO

54th CONGRESS / 54e CONGRÈS

Canadian Meteorological and Oceanographic Society (CMOS) Annual Congress

Congrès annuel de la Société canadienne de météorologie et d'océanographie (SCMO)

BUILDING SOCIETAL RESILIENCE to Changing Weather, Climate, Oceans and Environment

BÂTIR UNE RÉSILIENCE SOCIÉTALE face à l'évolution du temps, du climat, des océans et de l'environnement

Sunday May 24, 2020 to Thursday May 28, 2020 at the Delta Hotel, 101 Lyon St., Ottawa

Dimanche le 24 mai 2020 au jeudi le 28 mai 2020 à l'hôtel Delta, 101, rue Lyon, Ottawa

cmos.ca / scmo.ca

Local Organizing Committee
54th CMOS Congress, May 24-28, 2020 – Ottawa

as of March 3, 2020

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Ann McMillan mcmillan@storm.ca	Opening ceremony

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	NRCan, ECCC, CGU, CACOR etc.

LAC members unassigned; Tom Zagon, Hoy Chow

Student representatives; François Lapointe - flapo099@uottawa.ca, Maryam Yousefi - yousefi67@gmail.com, Ada Loewen - ada.loewen@gmail.com, Kenny Bala - kennybala97@outlook.com
#
Ex Officio; Qing Liao Qing.Liao@dfo-mpo.gc.ca or accounts@cmos.ca#

Members at large; Bob Jones, Leslie Malone, Ted Yuzyk

Science Programme Committee; Co-Chairs Gordon McBean, Len Barrie; Members, Ray Desjardins, Ann McMillan (Arctic theme), Jackie Dawson, Clark Richards, John Pomeroy and Ken Denman

CMOS-SCMO

Canadian Meteorological and Oceanographic Society

Société canadienne de météorologie et d'océanographie

TIME	ROOM	SESSION	CHAIR
May 26, 2020	**Tuesday - Day 1**		
11:00 - 12:30	Session 2	2010120 The Changing Arctic Atmosphere - Part 1	Kimberly Strong James Drummond
14:00 - 16:00		Publication Committee Meeting	Douw Steyn
13:00 - 14:30	Session 2	2010121 The Changing Arctic Atmosphere - Part 2	Kimberly Strong James Drummond
15:00 - 16:30	Session 1	2010370 Advances in Remote Sensing	Adam Bourassa
May 27, 2020	**Wednesday - Day 2**		
11:00 - 12:30	Session 3	2010110 Land, Agriculture and Climate - Part 1	Shannon Brown Catherine Champagne
13:00 - 14:30	Session 3	2010111 Land, Agriculture and Climate - Part 2	Alexander Moravek Catherine Champagne
15:00 - 16:30	Session 3	2010112 Land, Agriculture and Climate - Part 3	Elizabeth Pattey Catherine Champagne
May 28, 2020	**Thursday - Day 3**		
11:00 - 12:30	Session 5	2010130 Climate Variability and Predictability - Part 1	Hai Lin
13:00 - 14:30	Session 5	2010131 Climate Variability and Predictability - Part 2	Bin Yu

15:00 - 16:30	Session 4	2010020 Precipitation Observations in the Arctic	Eva Mekis Gabrielle Gascon Dominique Brunet
May 29, 2020	**Friday - Day 4**		
11:00 - 12:30	Session 6	2010070 Actual climatology and anticipated changes in winter precipitation (solid, mixed and liquid) and hail and their impacts - Part 1	Sebastien Biner Dominique Paquin
13:00 - 14:30	Session 6	2010071 Actual climatology and anticipated changes in winter precipitation (solid, mixed and liquid) and hail and their impacts - Part 2	Sebastien Biner Dominique Paquin
June 01, 2020	**Monday - Day 5**		
11:00 - 12:30	Session 7	2010040 Northern tornadoes - Part 1	David Sills
13:00 - 14:30	Session 9a	2010360 Coastal Oceanography and Inland Waters - Part 1	Jinyu Sheng Guoqi Han
13:00 - 14:30	Session 7	2010041 Northern tornadoes - Part 2	David Sills
15:00 - 16:30	Session 9a	2010361 Coastal Oceanography and Inland Waters - Part 2	Jinyu Sheng Guoqi Han
June 02, 2020	**Tuesday - Day 6**		
13:00 - 14:30	Session 9b	2010362 Coastal Oceanography and Inland Waters - Part 3	Jinyu Sheng Guoqi Han
15:00 - 16:30	Session 9b	2010363 Coastal Oceanography and Inland Waters - Part 4	Jinyu Sheng Guoqi Han
June 03, 2020	**Wednesday - Day 7**		
13:00 - 14:30	Session 10	2010030 Atmosphere, Ocean, and Climate Dynamics - Part 1	Marek Stastna Adam Monahan
15:00 - 16:30	Session 10	2010031 Atmosphere, Ocean, and Climate Dynamics - Part 2	Adam Monahan Marek Stastna

June 04, 2020	**Thursday - Day 8**		
11:00 - 12:30	Session 11	2010350 Interdisciplinary and climate research on resilience - Part 1	Gordon McBean
13:00 - 14:30	Session 11	2010351 Interdisciplinary and climate research on resilience - Part 2	Gordon McBean
June 08, 2020	**Monday - Day 9**		
11:00 - 12:45	Session 13	2010150 Building resiliency in Health and Environment in a changing Climate	Melissa MacDonald
11:00 - 12:30	Session 12	2010190 Ocean-sea ice interaction in a changing climate: Environmental and societal impacts - Part 1	John Falkingham Angela Cheng
13:00 - 14:30	Session 13	2010010 Flood risks under climate change	Xander Wang
13:00 - 14:30	Session 12	2010191 Ocean-sea ice interaction in a changing climate: Environmental and societal impacts - Part 2	John Falkingham Angela Cheng
15:00 - 16:30	Session 17	2010250 Changing Arctic: Science and Policy Studies	David Fissel Helen Joseph
June 09, 2020	**Tuesday - Day 10**		
11:00 - 12:30	Session 15	2010080 Earth System Models As Tools For Societal Resilience - Part 1	Paul Kushner Kirsten Zickfeld
13:00 - 14:30	Session 15	2010081 Earth System Models As Tools For Societal Resilience - Part 2	Christopher Fletcher Nathan Gillett
June 11, 2020	**Thursday - CMOS Prizes and Awards Celebration**		
17:00 - 18:00		2020 CMOS Prizes and Awards Celebration	Kimberly Strong Denis Bourque
June 15, 2020	**Monday - Day 11**		
11:00 - 12:30	Session 16	2010210 Climate Change information supporting resilient infrastructure - Part 1	Jeremy Fyke

13:00 - 14:30	Session 16	2010211 Climate Change information supporting resilient infrastructure - Part 2	Francis Zwiers
15:00 - 16:30	Session 16	2010212 Climate Change information supporting resilient infrastructure - Part 3	Xuebin Zhang
June 23, 2020	**Tuesday - CMOS Annual General Meeting**		
14:00 - 16:00		CMOS Annual General Meeting	Kimberly Strong Gordon Griffith

Exhibits - Virtual Congress 54 - Ottawa 2020
Les exposants - Congrès virtuel 54 - Ottawa 2020

The following Exhibitors had selected and pre-paid for a booth at the Delta Hotel and were planning to come. CMOS thanks them for their support.

Les exposants suivants avaient sélectionné et payé à l'avance pour un stand d'exposition à l'hôtel Delta et prévoyaient venir. CMOS les remercie de leur soutien.

Amundsen Science

ASL Environmental Services

ATS Services Limited

CAF Weather

Campbell Scientific

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CMOS

Hoskin Scientific

Info-Electronics Systems Incorporated

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VAISALA

Abstracts of Papers Presented at the Virtual Congress 54

May 26 - June 15, 2020

Convenors: Dr. Kimberly Strong, Dr. James Drummond

The Arctic Atmosphere is changing rapidly due to many influences: changing composition, changing sea-ice, changing interactions with lower latitudes, and changing inputs from the land, snow, ice and oceans.

The Arctic region is known to be fragile and small changes in these inputs can have large effects and can be amplified strongly through feedback mechanisms. At the same time, the annual polar light/dark cycle instead of the daily cycle means that the atmosphere reacts differently to changes than does the atmosphere at lower latitudes. And making measurements is difficult because of the harsh environment and sparse measurement locations.

However understanding the changing Arctic atmosphere during both the summer and winter is an essential part of understanding the global atmosphere system.

This session invites papers on all aspects of the Arctic atmosphere including new instruments, new measurements, new sites, and new modeling efforts, and especially new insights into this complex and important atmospheric system.

Session: 2010120 The Changing Arctic Atmosphere - Part 1
L'atmosphère arctique en évolution - Partie 1 26/05/2020 11:00

ID: 10528 Invited session speaker

The Potential for a New Era in Arctic Greenhouse Gas, Air Quality and Weather Observations from Space

Ray Nassar [1]

[1] Environment and Climate Change Canada

Presented by / Présenté par: ***Ray Nassar***
Contact: ray.nassar@canada.ca

The Arctic is changing and atmospheric observations from space offer new possibilities for observing and monitoring these changes that complement ground-based methods. The Atmospheric Imaging Mission for Northern Regions (AIM-North) is a satellite mission currently undergoing Phase 0 (feasibility) study by the Canadian Space Agency (CSA) in partnership with Environment and Climate Change Canada (ECCC), along with industry partners and university scientists. Using a pair of satellites in a highly elliptical orbit (HEO) formation, AIM-North would address the gap in greenhouse gas (GHG) and air quality (AQ) observations over the Arctic that will result from the new constellations of geostationary (GEO) satellites of the 2020s. AIM-North would make dense ultraviolet-visible (UV-vis) and near to shortwave infrared (NIR-SWIR) spectral imaging observations in order to map CO2, CH4, CO, O3,

NO2, BrO, HCHO, SO2, aerosols, clouds and solar induced fluorescence (SIF) from vegetation spanning land from ~40 -80°N, with revisit times of 2 hours or less during daylight. These observations would improve our ability to monitor changes in the Arctic related to the transport of pollution or the changing carbon cycle, including CO2 and CH4 emissions from permafrost thaw, among other applications. The unique capabilities of observing from the HEO vantage point are also of interest to a number of international organizations with which Canada is now discussing partnership possibilities regarding meteorological and/or space weather payloads. Such scenarios would lead to a mission with expanded capabilities, greater synergy and the potential for overall cost savings relative to each organization pursuing separate HEO missions. This presentation will give an overview of the AIM-North mission and an update on the status of partnership discussions toward an expanded international Arctic Observing Mission (AOM).

Session: 2010120 The Changing Arctic Atmosphere - Part 1
L'atmosphère arctique en évolution - Partie 1 26/05/2020 11:20

ID: 10308 Contributed abstract

Arctic atmospheric temperature change driven by CO2

Yi Huang [1]

[1]

Presented by / Présenté par: ***Yi Huang***
Contact: Yi.Huang@mcgill.ca

Atmospheric temperature change is an important aspect of Arctic climate change and raises many intriguing questions. The climate model-projected atmospheric temperature change in the Arctic exhibits a unique vertical structure different from other regions. The Arctic tropospheric temperature change is bottom heavy, in shear contrast to the tropics. There is also a distinct warming pocket in the lower stratosphere that is not found anywhere else. To ascertain the causes of atmospheric temperature changes, we employ a hierarchy of numerical models to simulate the Arctic atmospheric temperature change under the CO2 forcing. This modeling analysis elucidates how different physical processes, including radiation, convection and circulation, contribute to the temperature structure change.

Session: 2010120 The Changing Arctic Atmosphere - Part 1
L'atmosphère arctique en évolution - Partie 1 26/05/2020 11:30

ID: 10513 Contributed abstract

Atmospheric Science at the Polar Environment Atmospheric Research Laboratory (PEARL)

Kimberly Strong [1] , *James Drummond* [2] , *The PEARL Team* [3]

[1] University of Toronto
[2] Dalhousie University
[3] various

Presented by / Présenté par: ***Kimberly Strong***
Contact: james.drummond@dal.ca

The Polar Environment Atmospheric Research Laboratory (PEARL) at Eureka, Nunavut is located about halfway up Ellesmere Island, right on the 80N North latitude line and 1,100km from the North Pole. Eureka has been home to an Environment and Climate Change Canada (ECCC) weather station since 1947. In 2005, a group of university and government researchers operating as an informal group called the Canadian Network for the Detection of Atmospheric Change (CANDAC) substantially expanded both the equipment and the research domain of an existing facility at the site, renaming it PEARL. PEARL operates as an all-year atmospheric observatory and hosts upwards of 25 research instruments, with considerable capacity for remote operations as well as on-site activities.

The large number of contemporaneous measurements at PEARL offers some unique opportunities to spot linkages between atmospheric phenomena that might be missed by a smaller, more focussed effort. The cross-support provided by the various teams, along with the on-site resources and technical staff, enhances the success of the overall enterprise, and also provides a very effective learning environment for students and other young researchers in what might otherwise be a very challenging location for measurements.

Scientific studies at PEARL primarily address topics related to climate, Arctic pollution and ozone. This talk will present some of the research conducted at PEARL, highlighting some of the unique challenges and successes, with some segues into the history and other adventures associated with running a 365/24 research observatory near the top of the world.

Up until 2020, PEARL has supported by network of the Canadian Climate and Atmospheric Research (CCAR) program of the Natural Sciences and Engineering Research Council (NSERC), by ECCC, and by the Canadian Space Agency. We hope that this funding, as well as new partners, will ensure that PEARL continues to operate into the 2020s, providing a unique window on Canada's high Arctic atmosphere.

Session: 2010120 The Changing Arctic Atmosphere - Part 1
L'atmosphère arctique en évolution - Partie 1 26/05/2020 11:40

ID: 10454 Contributed abstract

Gravity wave observations and ray tracing in the High Arctic atmosphere

Dustin Fraser [1] , *William Ward* [2] , *Peter Preusse* [3] , *Cornelia Strube* [4] , *Samuel Kristoffersen* [5] , *Dustin Gamblin* [6]

[1] University of New Brunswick
[2] University of New Brunswick
[3] Forschungszentrum Jülich GmbH
[4] Forschungszentrum Jülich GmbH
[5] University of New Brunswick
[6] University of New Brunswick

Presented by / Présenté par: ***Dustin Fraser***
Contact: dustin.fraser111@unb.ca

It is of great interest to study sources and mechanisms for gravity wave generation given the role of gravity wave dynamics in the MLT region on forcing the global pole-to-pole circulation. In this study, the nature and sources of these waves in the Arctic upper atmosphere are investigated using a combination of observations and ray tracing. Several gravity waves detected above Eureka, NU (80N, 86W) using instrumentation at the Polar Environment Atmospheric Research Laboratory (PEARL) are identified and detailed in this project. The E-Region Wind Interferometer (ERWIN) and PEARL All-Sky Imager are particularly important in observing waves via Doppler shifts (wind) in, and emission rate fluctuations of, hydroxyl (OH), sodium (Na), and green line (O) airglow emissions, respectively. Analysis of these emissions is performed to determine relevant input wave parameters for ray tracing, including wave vectors, ground-based frequencies, and amplitudes, among others. The Gravity wave Regional Or Global RAy-Tracer (GROGRAT), developed by Marks and Eckermann, is used for computing both wave packet trajectories and wave parameter evolution backwards in time. The background atmosphere through which the waves travel and necessary for GROGRAT runs is derived primarily from the extended Canadian Middle Atmosphere Model (CMAM). Initial results from GROGRAT runs on several waves detected above Eureka are discussed. The overall goal of this research project is to study sources and propagation of gravity waves observed in the northern polar atmosphere. This work sets the basis for a broader climatological study of gravity waves observed in the polar MLT region.

Session: 2010120 The Changing Arctic Atmosphere - Part 1
L'atmosphère arctique en évolution - Partie 1 26/05/2020 11:50

ID: 10359 Contributed abstract

Observations of inertia-gravity waves at high latitudes

Samuel Kristoffersen [1] , *William Ward* [2]

[1] University of New Brunswick
[2] University of New Brunswick

Presented by / Présenté par: ***Samuel Kristoffersen***
Contact: y6qk7@unb.ca

The E-Region Wind Interferometer (ERWIN-II) is a Michelson interferometer, located at the Polar Environment Atmospheric Research Laboratory (PEARL) in Eureka, Nu. Through measurements of the airglow irradiance winds are determined via Doppler shift in these airglow emissions – green line (557.7 nm) at a height of ~97 km, O2 (860 nm) at ~94 km, and OH (843 nm) at ~87 km. These measurements are of a high precision (~1 m/s for green line and OH, and~4 m/s for O2) and cadence (~5 minutes). This high temporal resolution allows for detection of frequencies of up to nearly the Brunt-Väisälä frequency, allowing for accurate detection and characterization of gravity wave phenomena. Observations of waves with quasi-tidal frequencies, 2-3 cycles per day, show characteristics akin to inertia-gravity waves. Therefore, a large number of low frequency gravity

waves may be occurring in the polar mesosphere.

Session: 2010120 The Changing Arctic Atmosphere - Part 1
L'atmosphère arctique en évolution - Partie 1 26/05/2020 12:00

ID: 10552 Contributed abstract

Wave coupling across the mesopause: a multi-instrument view from the Canadian High Arctic

William Ward [1] , *Alan Manson* [2] , *Marianna Shepherd* [3] , *Wayne Hocking* [4] , *Qian Wu* [5] , *Chris Meek* [6] , *Samuel Kristoffersen* [7] , *Dustin Gamblin* [8]

[1] University of New Brunswick
[2] University of Saskatchewan
[3] York University
[4] University of Western Ontario
[5] National Center for Atmospheric Research
[6] University of Saskatchewan
[7] University of New Brunswick
[8] University of New Brunswick

Presented by / Présenté par: ***William Ward***
Contact: wward@unb.ca

Waves are the main dynamical coupling mechanism between the various layers in the atmosphere. Their dissipation causes mixing and drives large scale global flows in the stratosphere and mesosphere. The details of these dynamical processes are still being explored. They are of particular interest near the poles because of the unique geometry there. A number of different instruments (meteor radars, all sky imagers and optical interferometers), located in the Canadian Arctic at Yellowknife (62 N, 114 W), Resolute Bay (75 N, 95 W) and at the Polar Environment Atmospheric Research Laboratory (PEARL) at Eureka (80 N, 85 W) have been taking observations of the mesopause region for over 6 years. These are part of the Canadian Space Agency funded Dynamics of the Neutral Thermosphere project and are supported through PEARL. In this paper, these observations will be reviewed and work undertaken to combine measurements from the various instruments discussed. Several sudden stratospheric warmings have occured during this observation period and the dynamical signatures of these warmings at these heights are summarized.

Session: 2010120 The Changing Arctic Atmosphere - Part 1
L'atmosphère arctique en évolution - Partie 1 26/05/2020 12:10

ID: 10412 Contributed abstract

Measurements of bromine monoxide over four halogen activation seasons in the Canadian high Arctic

Kristof Bognar [1] , *Xiaoyi Zhao* [2] , *Kimberly Strong* [3] , *Rachel Chang* [4] , *Udo Frieß* [5] , *Patrick Hayes* [6] , *Audra McClure-Begley* [7] , *Sara Morris* [8] , *Samantha Tremblay* [9] , *Andy Vicente-Luis* [10]

[1] Department of Physics, University of Toronto, Toronto, ON, Canada
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[4] Department of Physics and Atmospheric Science, Dalhousie University, Halifax, NS, Canada
[5] Institute of Environmental Physics, University of Heidelberg, Heidelberg, Germany
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[8] NOAA Earth System Research Laboratory, Boulder, CO, USA
[9] Department of Chemistry, University of Montreal, Montreal, QC, Canada
[10] Department of Chemistry, University of Montreal, Montreal, QC, Canada

Presented by / Présenté par: ***Kristof Bognar***
Contact: kbognar@physics.utoronto.ca

Ozone plays an important role in Arctic tropospheric chemistry. Episodic release of bromine during the spring leads to frequent ozone depletion events. The snowpack on sea ice and sea salt aerosols might both release bromine, but the relative contribution of each source is not yet known. Furthermore, the role of atmospheric conditions is not fully understood. Long-term measurements of bromine monoxide (BrO) at Eureka, Nunavut (80.1° N, 86.4° W) provide useful insight into the underlying processes of bromine activation in the Arctic. Here we present a four-year dataset (2016-2019) of springtime BrO partial columns retrieved from Multi -AXis Differential Optical Absorption Spectroscopy measurements, coupled with aerosol and weather observations, and back trajectory calculations. The elevation of the measurement site (610 m) provides a unique opportunity to examine BrO above the typically shallow boundary layer. We find that BrO is often present in the free troposphere, and the impact of mixing on the partial columns is only apparent for deep boundary layers during storms (winds above ~8 m/s). In general, BrO events show two modes differentiated by local wind direction and air mass history. Longer time spent in first-year sea ice areas corresponds to increased BrO for one of these modes only. While snow on first-year ice is commonly accepted as a source of bromine, we argue that snow on multi-year ice might also contribute to bromine release. In situ measurements indicate that accumulation mode aerosols (mostly Arctic haze) have no direct correlation with BrO. The presence of coarse mode aerosols, however, is a necessary and sufficient condition for observing enhanced BrO at Eureka (R2 up to 0.56). The measurements of coarse mode aerosols are consistent with sea salt aerosol generated from blowing snow, and support the view that aerosols are a direct source of bromine to the polar troposphere.

Session: 2010120 The Changing Arctic Atmosphere - Part 1
L'atmosphère arctique en évolution - Partie 1

26/05/2020
12:20

ID: 10395 Contributed abstract

On the Development of Water Vapor Retrievals from the PARIS-IR Arctic Springtime Dataset

Paul Jeffery [1] , *Kaley Walker* [2] , *Lin Dan* [3] , *James Drummond* [4] , *Ellen Eckert* [5] , *Pierre Fogal* [6] , *Dejian Fu* [7] , *Debora Griffin* [8] , *Ashley Harrett* [9] , *Felicia Kolonjari* [10] , *Gloria Manney* [11] , *Kimberly Strong* [12]

[1] University of Toronto
[2] University of Toronto
[3] University of Toronto
[4] Dalhousie University
[5] University of Toronto
[6] University of Toronto
[7] Jet Propulsion Laboratory/California Institute of Technology
[8] Environment and Climate Change Canada
[9] University of Toronto
[10] Environment and Climate Change Canada
[11] NorthWest Research Associates/New Mexico Institute of Mining and Technology
[12] University of Toronto

Presented by / Présenté par: ***Paul Jeffery***
Contact: paul.jeffery@mail.utoronto.ca

The Arctic is warming at a rate approximately twice that of the global mean, an effect known as Arctic amplification wherein changes in the Arctic climate are magnified due radiative feedback pathways. Studying changes in trace gases, in particular water vapour which acts as a key species for a variety of amplification processes, can then lead to a more thorough understanding of the changing Arctic conditions. One instrument that has been used to study atmospheric composition in the Arctic is the medium-resolution Portable Atmospheric Research Interferometric Spectrometer for the InfraRed (PARIS-IR). Between 2004 and 2017 PARIS-IR made measurements at the Polar Environment Atmospheric Research Laboratory (PEARL; 80.05° N, 86.42° W) located in Eureka, Nunavut, as part of the Canadian Arctic ACE/OSIRIS Validation Campaigns. These yearly campaigns commence in late February, just after polar sunrise, and continue for approximately six weeks. During this period PARIS-IR recorded solar absorption spectra every seven minutes, weather permitting, between 750 - 4400 cm-1 with a 0.02 cm-1 spectral resolution. Prior studies of the PARIS-IR Arctic springtime dataset have focused on eight trace gas retrievals (O3, HNO3, HCl, HF, CH4, C2H6, N2O, and CO). The focus of this study is on expanding this product list with a retrieval for water vapour. The development of this product is complicated by the strong vertical gradient and high variability of atmospheric water vapour, which routinely varies by several orders of magnitude at a given altitude. In this presentation, the development and implementation of the PARIS-IR water vapor retrieval will be examined, and comparisons will be made between these and coincident measurements made by other instruments including ACE-FTS and in-situ radiosondes.

Convenors: Dr. Kimberly Strong, Dr. James Drummond

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interactions with lower latitudes, and changing inputs from the land, snow, ice and oceans.

The Arctic region is known to be fragile and small changes in these inputs can have large effects and can be amplified strongly through feedback mechanisms. At the same time, the annual polar light/dark cycle instead of the daily cycle means that the atmosphere reacts differently to changes than does the atmosphere at lower latitudes. And making measurements is difficult because of the harsh environment and sparse measurement locations.

However understanding the changing Arctic atmosphere during both the summer and winter is an essential part of understanding the global atmosphere system.

This session invites papers on all aspects of the Arctic atmosphere including new instruments, new measurements, new sites, and new modeling efforts, and especially new insights into this complex and important atmospheric system.

Session: 2010121 The Changing Arctic Atmosphere - Part 2
L'atmosphère arctique en évolution - Partie 2 26/05/2020 13:05

ID: 10340 Contributed abstract

Science in the High Arctic - The Impact of High Arctic Weather Stations

Pierre Fogal [1] , *John Gilbert* [2]

[1] University of Toronto, Dept. of Physics
[2]

Presented by / Présenté par: ***Pierre Fogal***
Contact: pierre.fogal@utoronto.ca

From 1947 to 1950 five weather stations were established in the Canadian High Arctic from Isachsen and Mould Bay in the Western Arctic to Alert, Eureka and Resolute Bay to the east. The primary mission of the stations was meteorology but extended to obtaining as much scientific data concerning the Arctic as possible. Accommodation at the stations was provided without charge for visits of short duration and the stations were used as bases for geological and biological field work and ice reconnaissance. In the first 5 years scientists using the stations as their base investigated wildlife (birds and mammals), northern insects, soil, vegetation and archaeological sites.

By the end of the International Geophysical year in 1957, research covered the eleven earth sciences of relevance to the High Arctic: aurora and airglow, cosmic rays, geomagnetism, gravity, ionospheric physics,longitude and latitude determinations (precision mapping), meteorology, oceanography, seismology, and solar activity.

Following on in that scientific legacy, atmospheric science observatories have been established at both Alert and Eureka, with the Dr. Neil Trivett Global Atmosphere Watch Observatory operated by Environment and Climate Change Canada (ECCC) at Alert, and the Polar Environment Atmospheric Research Laboratory (PEARL) operated by the Canadian Network for the Detection of Atmospheric Change (CANDAC), at Eureka. PEARL instrumentation provides data on the atmosphere from the surface to low Earth orbit, and consists of state-of-the-art instruments measuring ultra-violet and infra-red radiation, as well as various radars and lidars. We will review the establishment and the on-going operation of PEARL and its relationship with the ECCC Eureka Weather Station.

Session: 2010121 The Changing Arctic Atmosphere - Part 2
L'atmosphère arctique en évolution - Partie 2 26/05/2020 13:15

ID: 10338 Contributed abstract

Automated Products for Forecasting Arctic Blizzard Conditions

William Burrows [1] , *Curtis Mooney* [2]

[1] ECCC/ASTD
[2] ECCC/MSC

Presented by / Présenté par: ***William Burrows***
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Blizzards are high impact Arctic weather events lasting from a few hours to several days. The Meteorological Service of Canada (MSC) criteria for issuing blizzard warnings are sustained wind = 40 kph and visibility = ¼ SM in snow and/or blowing snow for at least 4 hours south of 60°N and 6 hours north 60°N. Important environment factors are: below freezing temperature; strong wind for a few hundred meters above the ground; snowpack depth at least 1 cm; a source of snow; and degree of open terrain. Secondary factors are the age of the snowpack and the degree of convective stability near the ground. We find over half the occurrences of blizzard conditions in the Canadian Arctic are "clear sky" events due to blowing snow alone. MSC's National Lab-West runs 3 automated products in real time for forecasting blizzard conditions. These are driven by post-processed output from the Canadian Center for Meteorological and Environmental Prediction (CCMEP) global, regional, and high resolution NWP models. Display is on an internal website accessible to all forecast offices across Canada. The forecasts are generated from: 1) a set of expert's forecast rules (the Blizzard Potential); 2) the probability of visibility < ½ SM in blizzard conditions, derived by analysis of many years of radiosonde profiles by Baggaley and Hanesiak (2005); and 3) a model-output-statistics forecast derived by applying a machine-learning algorithm (RandomForest) to a two-year data-base of observations matched with a set of 43 physically related predictors generated from NWP model output. We will show modelling methods, examples of output, and verification results.

Session: 2010121 The Changing Arctic Atmosphere - Part 2
L'atmosphère arctique en évolution - Partie 2 26/05/2020 13:25

ID: 10355 Contributed abstract

Lidar Stratospheric Ozone Measurements in Eureka

Alexey Tikhomirov [1] , *Ghazal Farhani* [2] , *Emily McCullough* [3] , *Robert Sica* [4] , *Pierre Fogal* [5] , *Kaley Walker* [6] , *Thierry Leblanc* [7] , *James Drummond* [8]

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Presented by / Présenté par: ***Alexey Tikhomirov***
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The depletion of the stratospheric ozone layer has been a world-wide concern since a discovery of an ozone hole in Antarctica in 1980. Ozone depletion occurs in the Arctic as well. Recently severe ozone losses in the Arctic, comparable with the Antarctic ozone losses, have been reported in the literature. Thus, the monitoring of ozone changes is still necessary and continuing existing long-term measurements is valuable.
The Stratospheric Ozone Differential Absorption Lidar located at the Polar Environment Atmospheric Research Laboratory in Eureka, Nunavut (80 N, 86 W) has been a powerful tool for the measurement of stratospheric ozone vertical profiles and satellite data validation in the Canadian High Arctic since 1993. In this report we present the results of the ozone measurements carried out during 2017 -2020 Canadian Arctic Atmospheric Chemistry Experiment (ACE) and Optical Spectrograph and InfraRed Imaging System (OSIRIS) Validation Campaigns. Highly variable Arctic conditions bring certain challenge for validation campaigns. Non -optimal temporal and spatial coincidence between the measurements conducted by different instruments affects validation accuracy. However, the analyses show 10-15% agreement between lidar and ozonesonde, ACE-FTS, ACE-MAESTRO and OSIRIS measurements for most of the cases which is encouraging. Long-term data measurements of stratospheric ozone obtained from ground based instruments, including lidar, provide significant contributions to stratospheric ozone trend detection, as well as being an anchor site for validation of satellite measurements.

Session: 2010121 The Changing Arctic Atmosphere - Part 2
L'atmosphère arctique en évolution - Partie 2 26/05/2020 13:35

ID: 10224 Contributed abstract

Multi-Decadal Trends in Lower Tropospheric Arctic Aerosols, Black Carbon, Ozone and Mercury at Alert, Canada

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Presented by / Présenté par: ***Leonard Barrie***
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Observations from 1980 to 2013 of 20 aerosol constituents, ozone and mercury at Alert, Canada

(82.50° N, 62.35° W) were analyzed for trends and dominant factors of the Arctic haze during winter and spring. Trends reflect changing emissions in Eurasia, the main source region for surface pollution in the high Arctic. SO42-, H+, NH4+, K+, Cu, Ni, Pb, Zn, non-soil V, non-soil Mn, and equivalent black carbon (EBC) decreased between 23 and 80% as emissions declined rapidly in northern Eurasia during the early 1990's. NO3- increased by 20% as aerosol acidity declined. Metals were linked to emissions from smelting and fossil fuel combustion. In winter, ozone increased by 5% over 23 years, consistent with other observations and global modelling. Twelve PMF factors emerged for the dark period (Nov to Feb) and 13 for the light period (Mar to May). Eleven PMF factors are common to both dark and light, a twelfth factor was associated with sulfate in the dark and nitrate in the light, and the thirteenth (light period), was related to ozone and gaseous mercury depletion near Alert. IODINE and NITRATE factors, important for Arctic chemistry, changed with sunlight. In light, 50% of all NO3- was on the NITRATE factor while in dark, most was associated with MODIFIED SEA SALT and EBC. In the dark (light), 90% (28%) of iodine were found on the factor IODINE and 58% associated with SEA-SALT and MODIFIED SEA-SALT. These results help in understanding the role of atmospheric chemistry in weather and climate processes.

Session: 2010121 The Changing Arctic Atmosphere - Part 2
L'atmosphère arctique en évolution - Partie 2 26/05/2020 13:45

ID: 10392 Contributed abstract

Comparisons of columnar aerosol parameters obtained from Arctic AERONET retrievals with GEOS-Chem-TOMAS simulations

Yasmin Aboel Fetouh [1] , *Norm O`Neill* [2] , *Jack Kudros* [3] , *Jeff Pierce* [4] , *Huizhong Lu* [5] , *Keyvan Ranjbar* [6]

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Presented by / Présenté par: ***Yasmin Aboel Fetouh***
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Quantitative assessment of aerosol microphysical and optical properties in climate models is essential to improving their simulations. Representation of high-latitude aerosols in climate models still poses a significant challenge and a critical radiative forcing shortcoming given the important role of aerosols via their direct and indirect effects. The rapid climate-change impacts currently occurring in the Arctic, behooves a proper modelling of their microphysical and optical properties, as well as their essential physical processes.
In this study, we investigated simulations of the TwO-Moment Aerosol Sectional (TOMAS) microphysics package implemented in the GEOS-Chem model. The simulations, whose output includes aerosol mass concentrations over a 3D Arctic domain, incorporate microphysical processes such as nucleation, condensation, and coagulation within a context of 40 particle size bins stretching

across a particle diameter range from 0.001 μm to 10 m. We compare a year of simulations (2015) with the particle size distributions, fine, and coarse mode aerosol optical depths (AODs) and fine and coarse mode effective radii results of the multi-year AERONET retrieval (Dubovik inversion) climatology of Aboel-Fetouh et al. (2020) as well as the AERONET retrieval averages for 2015.
The preliminary PSDs comparisons show that the model captures some of the AERONET coarse mode trends but fails to capture the spring to summer increase in the fine mode effective radius. The TOMAS values of the fine mode AOD generally follow the AERONET seasonal trend except for the month of June at Barrow. There appears to be, with the exception of PEARL and Thule, a tendency for TOMAS to underestimate values relative to both the 2015 and climatological-scale averages of the AERONET retrievals.

Session: 2010121 The Changing Arctic Atmosphere - Part 2
L'atmosphère arctique en évolution - Partie 2 26/05/2020 13:55

ID: 10393 Contributed abstract

Analysis of the exceptional Arctic-wide, smoke and volcanic UTLS fine-mode events during the summer of 2019 : comparison of TROPOMI, AERONET AEROCAN, and CALIOP aerosol products for the SACIA (Signatures of Aerosol-Cloud Interaction over the Arctic) project

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Presented by / Présenté par: ***Keyvan Ranjbar***
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The summer of 2019 was quite active in terms of pyroCb (smoke) and volcanic (SO2/sulphate) intrusions into the Arctic stratosphere from, respectively, biomass burning in northern Russia and the Raikoke (Russian) volcano. These intrusions, that our ground-based climatologies indicated were significantly of greater fine-mode (sub-micron) aerosol optical depth amplitude than the Arctic-summer norm, dispersed into an Arctic- wide, fine mode UTLS (Upper Tropospheric, Lower Stratospheric) aerosol phenomenon that was captured by numerous satellite and ground-based sensors. As part of our SACIA (Signatures of Aerosol -Cloud Interaction over the Arctic) project, ground-based AERONET/AEROCAN retrievals, satellite-based passive imagery products (TROPOMI, VIIRS and MODIS), satellite -based lidar profiles (CALIOP) and aerosol modelling simulations were employed to investigate the detailed dynamics of the 2019 events. Part of this investigation involved an evaluation of the TROPOMI (A- band) plume products (aerosol layer height and aerosol -layer optical thickness) in relation to analogous products derived from CALIOP vertical profiles of extinction coefficient. A preliminary analysis of the results will be presented.

Session: 2010121 The Changing Arctic Atmosphere - Part 2

ID: 10391 Contributed abstract

New observational methods towards understanding aerosol-cloud interactions over the Arctic

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Presented by / Présenté par: ***Lauren Zamora***
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Cloud phase, cloud lifetime, and precipitation are strong influences on the Arctic surface energy budget, which in turn affects sea ice melt and sea ice interannual variability. Previous results show that aerosols can have a large impact on these cloud properties, but that aerosol co-variation with meteorology can lead to inaccurate estimates of aerosol microphysical effects. We present a new method, using over 7 million cloud, aerosol, and meteorological profiles from satellite and reanalysis products, to demonstrably account for such co-variability. This method, developed in a previous study external to the Arctic, offers insight into the aerosol microphysical effects on clouds over large scales that could not otherwise be observed in smaller-scale studies. (That study, for example, gives evidence that dust effectively scrubs the atmosphere of precursors of marine cloud-active particles that later would have increased deep-convective-cloud frequency.) Applying this method over the Arctic could improve our understanding of aerosol-cloud interactions from various aerosol source types in this region as well. However, because the Arctic is poorly sampled compared to other regions, we require better validation of key aerosol parameters to develop confidence in this application. Thus, in the current study, we compare 8 years of satellite observations over poorly sampled marine regions with Arctic aerosol properties from model and reanalysis products. These results are an important step toward understanding the factors driving the large-scale aerosol impacts on clouds over the Arctic region that, until now, have been too challenging to observe.

Session: 2010121 The Changing Arctic Atmosphere - Part 2

ID: 10449 Contributed abstract

Monitoring moisture transport into the Arctic UTLS and its role in cloud formation: recent findings from the SACIA (Signatures of Aerosol-Cloud Interaction over the Arctic) UTLS project

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Presented by / Présenté par: ***Liviu Ivanescu***
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The investigation of cloud formation mechanisms in the UTLS (Upper-Troposphere/Lower-Stratosphere) is a core activity of our SACIA (Signatures of Aerosol-Cloud Interaction over the Arctic) project. Aerosol transport along potential temperature lines inside the Arctic dome, with subsequent subsidence to the tropopause was demonstrated in previous communications. We hypothesize that water vapor, the cardinal driver of cloud formation, should follow similar transport paths. In this study, we focus on illustrating such a mechanism and its contribution to cloud nucleation. To this end, the period following the energetic Kasatochi (Aleutian Islands, 52oN) volcano eruption of 8th August, 2008 was particularly revealing. The long-range moisture transport and lifting dynamics are brought into relief by the temperature and humidity profiles provided by the NOAA Atmospheric Infrared Sounder (AIRS) and the Advanced Microwave Sounding Unit (AMSU) aboard the Aqua satellite. These profiles provide a particulate dynamics context for the Calipso lidar and CloudSat radar profiles acquired about a minute later along their common A-train orbit. The temporal evolution of the water vapor condensation process at the tropopause is also observed by the ground-based lidar (CRL or CANDAC Rayleigh-Mie-Raman Lidar) and radar (MMCR or Milli-Meter Cloud Radar) at the Eureka Weather Station (80oN). The moisture dynamics at the cloud interface can be investigated using high resolution radiosondes profiles.
In order to understand how the Kasatochi mechanisms might be generalized, we applied the same investigative framework to the August 2017 pyrocumulonimbus (pyroCb) forest firestorm in Western Canada, along with recent (intense) pyroCb and volcanic (Raikoke) events in the summer of 2019. In these cases the moisture profiles were provided by the Cross-track Infrared Sounder (CrIS) and the Advanced Technology Microwave Sounder (ATMS) aboard the Suomi NPP satellite.

Convenor: Adam Bourassa, Paul Kushner

Contributions relating to new developments in instrumentation, retrieval techniques, and data products for satellite based atmospheric measurements.

Session: 2010370 Advances in Remote Sensing Progres de la télédétection
26/05/2020 15:00

ID: 10360 Contributed abstract

Comparisons of TROPOMI CH4 measurements with ACE-FTS

Tyler Wizenberg [1] , *Kimberly Strong* [2] , *Kaley Walker* [3] , *Sébastien Roche* [4] , *Claus Zehner* [5] , *Ilse Aben* [6] , *Jochen Landgraf* [7]

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Presented by / Présenté par: ***Tyler Wizenberg***
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The Atmospheric Chemistry Experiment (ACE) Fourier transform spectrometer (FTS) is a high-spectral-resolution (0.02 cm-1) interferometer that was launched aboard the Canadian SCISAT satellite in August 2003. Since 2004, it has been making solar occultation limb measurements from which trace-gas profiles are retrieved. It is currently one of the only satellite-borne instruments that is capable of retrieving high-vertical-resolution (~3km) atmospheric profiles of CH4. In this work, we compare global TROPOMI version 010202 CH4 data products with ACE-FTS to quantify how closely the TROPOMI measurements correlate with those from ACE -FTS. We convert ACE-FTS vertical volume mixing ratio profiles into column-averaged dry-air mole fractions to enable comparisons of the measurements from these two instruments. Measurements of CH4 made by a Bruker IFS 125HR Fourier transform infrared spectrometer located at the Polar Environment Atmospheric Research Laboratory (PEARL) at Eureka, Nunavut (80°N, 86°W) are also included in the comparisons for additional context.

Session: 2010370 Advances in Remote Sensing Progres de la télédétection
26/05/2020 15:13

ID: 10474 Contributed abstract

The Spatial Heterodyne Observations of Water instrument – a potential contribution to NASA A-CCP

Jeffery Langille [1] , *Adam Bourassa* [2] , *Doug Degenstein* [3] , *Jean-Pierre Blanchet* [4] , *Brian Solheim* [5]

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Presented by / Présenté par: ***Jeffery Langille***
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The Spatial Heterodyne Observations of Water instrument is a limb imaging satellite prototype that has been developed to provide accurate, dense, high vertical resolution measurements of water vapour in the upper troposphere and lower stratosphere. In this region, the radiative sensitivity of water vapour is

most significant, and its distribution is coupled to the climate in a complex manner with potential feedbacks and strong connections to cloud and aerosol processes. The instrument utilizes a field widened spatial heterodyne spectrometer operating in the limb viewing configuration to observe limb scattered sunlight in a small 3 nm spectral window centered near 1365 nm. Vertically resolved images of the limb are obtained with each frame that are inverted using non-linear optimal estimation to extract the vertical distribution of water vapour. The large throughput and high spectral resolution (0.02 nm) provided by the field widened SHS allows vertical profiles with a target vertical resolution of < 250 m to be obtained with rapid along track sampling (~50 km) from a low earth orbit satellite. The instrument is one of three instruments that have been proposed as a potential Canadian contribution to NASA's aerosol, clouds, convection, precipitation (ACCP) mission. Synergistic observations of aerosol and cloud are obtained by the other two instruments, ALI and TICFIRE allowing for a detailed picture of aerosol, water vapour and cloud interactions. This paper presents the SHOW instrument concept, scientific results from a sub-orbital demonstration flight on board NASA's ER-2, as well as the mission concept and user/science requirements for an upcoming satellite mission.

Session: 2010370 Advances in Remote Sensing Progres de la télédétection

26/05/2020 15:26

ID: 10525 Contributed abstract

The Thin Ice Clouds in Far IR Experiment (TICFIRE): a potential Canadian contribution to NASA A-CCP

Jean-Pierre Blanchet [1], *Pierre Gauthier* [2], *Yann Blanchard* [3], *Yi Huang* [4], *Adam Bourassa* [5], *Doug Degenstein* [6], *Kim Strong* [7], *Norm O'Neill* [8]

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Presented by / Présenté par: ***Jean-Pierre Blanchet***
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Processes and feedback mechanisms involving clouds and aerosols represent one of the largest sources of uncertainty in our understanding of Earth's climate system. Through their modulation of radiation, precipitation, and atmospheric composition, clouds figure strongly in maintaining atmospheric and surface energy budgets. Their high spatiotemporal variability makes them difficult to observe and characterize. Even though more than half of Earth's emission to space occurs at long wavelengths, satellite observations of the spectrally-resolved far-infrared (FIR) (17 to 100 μm) are missing. Because radiative transfer is sensitive to particles whose sizes are comparable to the wavelength of radiation, 10-100 μm ice crystals interact much with FIR. Such crystals are key initiators of precipitation and

atmospheric water balance. Observations of radiation in the FIR are sensitive to crystal size, optical depth (water content), liquid-ice mixture, and water vapour concentration in the low limit. In recent years, we have successfully tested the FIR Radiometer (FIRR), a prototype of the TICFIRE instrument, through airborne and ground-based campaigns. Verification against the E-AERI at the PEARL facility in Eureka (80oN), at the Iqaluit supersite (YOPP) and theoretical calculations have demonstrated the high performance and the reliability of FIRR. Satellite measurements of FIR are essential but lacking, and this seriously compromises both the monitoring of trends in cloudiness, and the representation of cloud and precipitation processes in numerical weather and climate models. Based on a strong radiometric heritage, new FIR data are readily assimilated into operational weather forecasting systems. Joint with sister instruments ALI and SHOW for aerosol and water vapour, the tandem offers a strong synergy on aerosol, water, cloud, precipitation, and radiation interaction. These instruments are our Canadian candidates for potential contribution to the A-CCP NASA's decadal program for the 20's.

Session: 2010370 Advances in Remote Sensing Progres de la télédétection

26/05/2020 15:39

ID: 10466 Contributed abstract

The Aerosol Limb Imager: a potential contribution to NASA A-CCP

Doug Degenstein [1] , *Landon Rieger* [2] , *Daniel Letros* [3] , *Jean-Pierre Blanchet* [4]

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Presented by / Présenté par: ***Adam Bourassa***
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The Aerosol Limb Imager (ALI) is a remote sensing instrument concept for high vertical resolution profiling of aerosol extinction and cloud in the upper troposphere and lower stratosphere, where the aerosol direct effect on climate and aerosol-cloud interactions are critical. Hyperspectral measurements of limb scattered sunlight radiance in the mid-visible and near infrared are achieved by using a large aperture imaging quality acousto-optic tunable filter with a dual transducer that is capable of tuning over the spectral range 500-1600 nm with 2-15 nm spectral resolution. The combination of the wide spectral range and the polarization information in a non-linear inversion with a multiple scattering radiative transfer model allows for retrievals of aerosol extinction profiles, particle size distribution parameters, and cloud discrimination with a target vertical resolution of 250 m. The high-aspect ratio field-of-view provides cross track coverage for nearly global daily coverage from a polar, low earth orbit. Canada has proposed ALI as one of three contributed instruments to the NASA Decadal Survey satellite mission on Aerosol, Cloud, Convection and Precipitation (ACCP). The other two instruments, SHOW and TICFIRE, target synergistic observations of ice clouds and water vapuor. This talk will present the instrument concept, first results from a stratospheric balloon flight of an instrument prototype, and the user requirements for a future satellite mission.

Session: 2010370 Advances in Remote Sensing Progres de la télédétection

26/05/2020 15:52

ID: 10512 Contributed abstract

MOPITT at 20 Years

James Drummond [1] , *The MOPITT Team* [2]

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Presented by / Présenté par: ***James Drummond***
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The Measurements Of Pollution In The Troposphere (MOPITT) instrument was launched on 18th December 1999 on the Terra spacecraft. It was expected to complete its mission about five years after launch, but due to outstanding engineering from the team and a bit of luck both the instrument and the entire Terra satellite are still healthy after two decades.

MOPITT measures carbon monoxide (CO) over the globe providing a unique window of pollution in the troposphere. This long-time single-instrument series permits both short (seasonally) and long (decadal) studies. MOPITT has the unique of ability to provide altitude profiles and spatial information simultaneously and so it appropriate for studying regional events such as fire seasons. In additional, since MOPITT is carefully validated, it is possible to look at trends regionally and globally through two decades.

During the MOPITT mission, computer chemical models have matured into prediction “chemical weather” models as well. Now the synergy between these data and the models permit studies of emissions, other constituents and prediction.

In this talk some studies will be discussed showing the ability of MOPITT as a single-instrument, providing decades-long data. Some examples are regional, such as Indonesian fire seasons and the more recent Australian fire season and some are global, such as trends and inversions for emissions.

MOPITT was provided to NASA's Terra spacecraft by the Canadian Space Agency and was built by COMDEV of Cambridge, Ontario. Data processing is performed by the MOPITT team at the National Center for Atmospheric Research, Boulder, CO. Instrument control is by the MOPITT team at the University of Toronto.

Session: 2010370 Advances in Remote Sensing Progres de la télédétection

26/05/2020 16:05

ID: 10553 Contributed abstract

The MAESTRO spectrophotometer on the Canadian Space Agency’s SCISAT

satellite

Tom McElroy [1]

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Presented by / Présenté par: ***Tom McElroy***
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The CSA SCISAT satellite is now operating on orbit in its 17th year. The Measurement of Aerosol in the Stratosphere and Troposphere Retrieved by Occultation (MAESTRO) spectrophotometer continues to measure the stratosphere and upper troposphere. The instrument design and performance will be discussed and some interesting data collected by the instrument will be reviewed. MAESTRO is one of two instruments on board, the other being the ACE-FTS (Atmospheric Chemistry Experiment, Fourier Transform Spectrometer). MAESTRO makes 30 occultation measurements per day with a vertical resolution of just over 1 km. It measures from 500 nm to 1000 nm with a resolution of 1 to 2 nm. Data products include ozone, nitrogen dioxide, water vapour and aerosol extinction.

Session: 2010370 Advances in Remote Sensing Progres de la télédétection

26/05/2020 16:18

ID: 10468 Contributed abstract

The OSIRIS instrument on the Odin satellite: nearly 20 years of stratospheric composition

Doug Degenstein [1] , *Chris McLinden* [2]

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Presented by / Présenté par: ***Doug Degenstein***
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The Canadian designed and build Optical Spectrograph and InfraRed Imaging System (OSIRIS), is deployed and currently in operation aboard the Swedish Odin satellite. Launched in 2001, OSIRIS measures vertical profiles of spectrally dispersed, limb scattered sunlight from the upper troposphere into the lower mesosphere. These measurements are used to retrieve stratospheric ozone, aerosol, nitrogen dioxide, bromine monoxide, and temperature with daily coverage of the sunlight globe and high vertical resolution. With nearly 20 years of operations, the measurements are increasingly valuable as climate data records. This talk will highlight key contributions that OSIRIS has made to understanding ozone recovery, monitoring stratospheric aerosol for climate modelling, and toward understanding long term trends in reactive nitrogen.

Convenors: Catherine Champagne (lead convenor), Shannon Brown, Aston Chipanshi, Elizabeth Pattey, Ward Smith, Alexander Moravek

This session focuses on (1) understanding relationships between climate and land based resource sectors such as agriculture, forestry and water in order to ensure the resiliency of these sectors, as well as (2) measuring and simulating the impact of land-atmosphere interactions in a changing world.
We invite contributions (1) that expand our knowledge base on how we can use past, present and future climates to better adapt and reduce costs associated with climate change, variability and extreme events and (2) that improve our understanding on land-atmosphere exchange. We encourage submissions related (but not limited to) any of the following sub-themes:

1. Exploring productivity limitations under different climatic regimes.
2. Integrating climate extremes in ecosystem models.
3. Mainstreaming climate information in resource based sectors.
4. Trend, magnitude, frequency and severity analysis of sector specific climate indices under the past, present and future climate scenarios.
5. Empirical/process-based methods for estimating climate variability impacts on ecosystems across multiple spatio-temporal scales.
6. Translating weather forecasts into useful decision support tools for natural resource managers.
7. Remote sensing applications in land surface meteorology, agriculture and forestry.
8. Measurements of land-atmosphere exchange of energy, water, particles, greenhouse gases and other atmospheric pollutants.
9. Ecosystem models and land surface schemes exploring biophysical and biogeochemical processes underlying land-atmosphere interactions.
10. Methodological guidelines and standards for measuring and simulating land-atmosphere exchange.

Session: 2010110 Land, Agriculture and Climate - Part 1 Terre, agriculture et climat - Partie 1

27/05/2020 11:05

ID: 10491 Contributed abstract

Quantifying land-atmosphere interactions using aircraft-based flux measurements

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Presented by / Présenté par: ***Raymond Desjardins***
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Quantifying land-atmosphere interactions using aircraft-based flux measurements

R. Desjardins1, D. Worth1, I. MacPherson2, P. Schuepp3, and R. Srinivasan2
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ABSTRACT
The NRC Twin Otter atmospheric research aircraft has been used for over forty years to measure the fluxes of sensible heat, latent heat, carbon dioxide, methane, ozone, nitrous oxide and other trace gases over a wide range of ecosystems such as: agricultural regions (irrigated and non-irrigated), different types of forests, wetlands , urban areas, etc. We will describe the aircraft-based flux system and present some of the data collected. We will show examples of the versatility of this technology to gain a better understanding of land-atmosphere interactions for example 1) Mesoscale transfer associated with surface features, 2) Several cases where the tower-based flux measurements for certain scalars would to be underestimated, 3) Flux measurements downwind of a highway, 4) Flux measurements at the top of the nocturnal boundary layer, 5) A demonstration of the complexity of verifying agricultural methane inventory at a regional scale, etc. Finally, we will attempt to demonstrate that much more insight on land-atmosphere interactions can be obtained with this excellent data base.

Session: 2010110 Land, Agriculture and Climate - Part 1 Terre, agriculture et climat - Partie 1
27/05/2020 11:17

ID: 10509 Contributed abstract

Drivers and Variability of Nitrous Oxide Emissions from Annual Crops in Cold Climate

Claudia Wagner-Riddle [1] , *Khagendra Baral* [2] , *Shannon Brown* [3]

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Presented by / Présenté par: ***Claudia Wagner-Riddle***
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Nitrous oxide (N2O), a trace gas that contributes to the enhanced greenhouse effect and stratospheric ozone destruction, is the focus of climate change mitigation efforts in crop production due to its importance for the global agricultural greenhouse gas budget. The complex interplay of microbiological processes and soil conditions regulates N2O dynamics in the soil profile, and when N2O is released from the soil surface. Management practices (e.g. inorganic nitrogen addition) and weather (e.g. severity of winter freezing) are external factors driving this interaction, ultimately determining the magnitude of N2O production and large temporal variability in emission. Micrometeorological measurements of N2O flux at our long-term experiment site over the last two decades affords a unique opportunity to quantify the variability in annual N2O emissions and its main drivers. Here, we characterize annual N2O

emissions, N2O emission factors and N2O emission intensity for corn and soybeans with the objective of testing the 2000-2017 time series for trends. Preliminary results suggest during the growing season emissions from corn are several-fold higher than soybeans due to the additive effects of fertilisation and cultivation. Analysis suggests freeze-thaw emissions are higher following harvesting of soybeans than corn. Comparison with IPCC factors will also be presented.

Session: 2010110 Land, Agriculture and Climate - Part 1 Terre, agriculture et climat - Partie 1

27/05/2020 11:30

ID: 10374 Contributed abstract

Influence of cover crops, tillage, and rotation diversity on field-scale cropland soil N2O flux

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Presented by / Présenté par: ***Yuanpei Gao***
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Greenhouse gas (GHG) emission reduction has gained increasing interest as concerns about climate change grew in recent years. Nitrous oxide (N2O), a potent GHG that is mainly released by cropland soils through microbial activities, contributes to atmospheric warming and ozone depletion. Agricultural management practices, such as cover cropping and tillage, are important for reducing N2O emissions by modifying soil conditions that drive microbial N-transforming processes such as nitrification and denitrification. In addition, seasonal freezing of cropland soils also induces elevated N2O emission during spring thaw in cold climates, which is also influenced by management practices. However, effects of these management practices are not well understood due to inconsistent practices and lack of year-round measurements presented in past studies.

Here we measure year-round N2O flux with half-hourly resolution over four 4-ha plots that are managed under four treatments in terms of cover cropping, crop rotation, and tillage at the Elora Research Station in Ontario, Canada from 2018 to 2020. This two-part study focuses on short-term and long-term influences of the three management practices. Between May 2018 and April 2019, we focus on short-term effect of inter-seeded cover crops and tillage on N2O emission from corn, especially following harvesting and tillage in Fall 2018, and during spring thaw in 2019. With two plots having a diverse crop rotation (corn-soybean-winter-wheat) and the cover cropping in 2018 also acting as a mean of crop diversification, we study the long-term effect of crop diversification on N2O emission between May 2018 to April 2020 by comparing emissions to a conventional (corn-soybean) rotation.

A flux-gradient system and a variety of instrument are employed and carefully maintained to obtain N2O flux time series with minimized gaps. Complemented with soil and plant data, flux data are statistically compared across treatments and interpreted to determine long- and short-term effects on N2O emissions.

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27/05/2020 11:42

ID: 10405 Contributed abstract

How do Soil Type, Crop Rotation Diversity and Climate Change affect Freeze-Thaw Nitrous Oxide Emissions?

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Presented by / Présenté par: ***Rebecca Johnson***
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Nitrous oxide (N2O) is a potent greenhouse gas that contributes to global climate change. In Canada, agricultural soils provide 77 total N2O emissions. Emissions vary spatially and temporally and are challenging to capture during peak emission times such as after fertilizer application and during freeze-thaw cycles. Up to 90% of annual N2O emissions from croplands may be produced through freeze-thaw mechanisms. However, freeze-thaw N2O emissions are poorly quantified because short-lived N2O fluxes are challenging to capture. The lack of N2O data induced by freeze-thaw mechanisms is concerning because climate change is expected to increase the frequency and severity of freeze-thaw cycles over time which may enhance N2O emissions.

Soil management practices like crop rotation diversity can provide yield stability and improve crop resilience to climate change stressors; how N2O emissions are impacted by those changes is not well understood. Cover crops may reduce N2O emissions, but is dependent on many factors including soil type, residue management and fertilizer rate.

The purpose of this research is to understand how winter warming, crop rotation diversity and soil type affected freeze-thaw induced N2O emissions. To accomplish this goal, N2O emissions were measured using an automatic flux chamber system installed in 18 large monolithic soil lysimeters containing two different soil types, sandy-loam and silt-loam. Two crop rotation treatments were applied to the lysimeters starting in 2016, the simple rotation consisted of soybean-soybean-corn and the diversified rotation consisted of soybean-winter wheat-corn with a multi-species cover crop mix applied after winter wheat and into corn. Winter warming was simulated by overhead ceramic heaters that applied 2°C warming to half of the lysimeters in the diverse.

The automatic chamber gas sampling setup and warming experiment will be described. Preliminary results of N2O emissions from the 2018-19 and 2019-20 non-growing seasons will be presented along with supplementary data.

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27/05/2020 11:55

ID: 10459 Contributed abstract

New insights into the bi-directional exchange of ammonia from eddy covariance flux measurements above a corn crop canopy

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Presented by / Présenté par: ***Alexander Moravek***
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Emissions of ammonia (NH3) from agriculture have a significant impact on the environment. Its atmospheric transport and subsequent deposition has been shown to alter nutrient-poor ecosystems thereby reducing biodiversity. As the most abundant base in the atmosphere, NH3 plays a key role in secondary aerosol formation impacting air quality and climate. Due to the lack of long term observations and challenges in performing NH3 flux measurements, large uncertainties exist in the emission estimates from fertilized crop fields and in the bi-directional exchange of NH3 with ecosystems. We measured direct eddy covariance NH3 fluxes above a corn field using a quantum cascade laser spectroscopy analyzer. Measurements were performed from the fertilizer application in May to the start of the leaf senescence in October in two consecutive growing seasons in 2017 and 2018. We found that after initial NH3 emissions following fertilizer application, periods of both NH3 emission and deposition with similar flux magnitudes prevailed throughout the growing seasons, highlighting the importance of the corn crop canopy for regulating the net NH3 exchange. To evaluate the underlying processes of the NH3 bi-directional exchange, a two-layer compensation point model approach was used. Based on the large range of environmental conditions during the flux measurements, a new parameterization for modeling stomatal and non-stomatal flux pathways will be discussed.

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27/05/2020 12:07

ID: 10411 Contributed abstract

Monitoring urban greenhouse gases in downtown Toronto using open-path

Fourier transform spectroscopy

Yuan You [1] , *Brendan Byrne* [2] , *Kimberly Strong* [3] , *Orfeo Colebatch* [4] , *Jinwoong Kim* [5] , *Dylan Jones* [6] , *Pierre Fogal* [7] , *Richard Mittermeier* [8] , *Doug Worthy* [9] , *David Griffith* [10]

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Presented by / Présenté par: ***Yuan You***
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Urban areas are large sources of greenhouse gases (GHGs) to the atmosphere and measurements of atmospheric GHGs in urban areas provide useful data for estimating urban emissions. Open-path Fourier transform infrared (OP-FTIR) spectroscopy is a non-intrusive technique that can be used to simultaneously measure multiple atmospheric trace gases in the boundary layer. Here, we present two years of continuous measurements by an OP-FTIR system located in downtown Toronto, Canada. This system is used to retrieve CO2, CO, CH4, N2O, H2O, and HDO volume mixing ratios (VMRs) over a two-way total atmospheric open path of 320 m using non-linear least squares fitting. Our results show that retrieved VMRs of CO2, CO, CH4 and N2O are sensitive to urban emissions from Toronto. Diurnal and seasonal variations of these gases, as well as VMR ratios of CO, CH4 to CO2 are investigated to assess potential urban sources. This presentation also includes point measurements of gases from in situ analyzers at several sites around Toronto, including a site 5.4km south of the OP-FTIR site. Measurements at these sites are compared to results from the OP-FTIR system, and horizontal gradients in VMRs of gases between these sites are studied to assess the impact of urban emissions. Urban GHGs emissions can be estimated using a top-down approach that utilizes measurements, the WRF-STILT model, and prior emissions. This presentation describes the measurement results and the methodology for calculating emissions.

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27/05/2020 12:20

ID: 10306 Contributed abstract

Temperature Induced Spectroscopic Line-broadening Effects in Open-path Eddy Covariance CO2 Flux

Ivan Bogoev [1] , *David Holl* [2]

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Presented by / Présenté par: ***Ivan Bogoev***
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Open-path eddy covariance systems, based on broad-band non-dispersive infrared (NDIR) gas analyzers, are widely used for CO2 and H2O flux measurements in remote locations around the world, because of their low power consumption, fast response and reliable operation. Nevertheless, agreement between open- and closed-path CO2 fluxes has limited inter-site comparability, especially in cold or non-growing seasons and low-flux environments, where physiologically unreasonable CO2 uptake is often observed by the open-path systems. A possible explanation is sensor-surface heating from internal-electronics power dissipation and solar radiation, which causes unaccounted gas density changes in the optical path. Fast-response thermometers, co-located with the gas analyzer, have been used to correct these effects. However, the fragility of the thermometers has prevented the wide adoption of this approach.
A challenge for the open-path sensor design is that in-situ air temperature affects not only the gas density but also the broadened half-width and intensity of the spectral absorption lines. We hypothesize that fast air temperature fluctuations in the optical path of the gas analyzer can change the amount of absorbed light and cause errors in the CO2 concentration measurement. Because of the natural covariance of sensible and CO2 fluxes, such errors are well correlated with the vertical wind and can potentially propagate into flux calculations.
We used spectral -line parameters, obtained from the high -resolution transmission molecular spectroscopic database (HITRAN), to evaluate the temperature effects on the integrated absorption spectra of CO2-air-mixtures across the 4.2 to 4.3 μm infrared active region utilized by NDIR analyzers. Results show that air temperature strongly influences absorption, and if not properly corrected, potentially introduces biases in the CO2 concentration measurements. Strong lines exhibit Doppler broadening, where the line peak and width decline with increasing temperatures, causing underestimation of CO2 concentration. Weak lines exhibit the opposite behavior. Based on our simulations, optimizing the optical filter pass -band can balance these opposing effects and greatly reduce the temperature dependence. In practice, manufacturing tolerances, shifts in the center wavelength, and the temperature sensitivity of the optical filters prevent complete elimination of the temperature-line broadening. A 13 nanometer shift in the filter pass band can introduce a 0.008 mmol m^{-3} K^{-1} underestimation in the CO2 concentration, which is a 0.67 μmol m^{-2} s^{-1} systematic error in CO2 flux per 100 watts of sensible heat flux.

Session: 2010110 Land, Agriculture and Climate - Part 1 Terre, agriculture et climat - Partie 1

27/05/2020 12:25

ID: 10450 Contributed abstract

Controls on Autotrophic and Heterotrophic Respiration in an Ombrotrophic Bog

Tracy Rankin [1] , *Nigel Roulet* [2] , *Tim Moore* [3] , *Elyn Humphreys* [4]

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Presented by / Présenté par: ***Tracy Rankin***
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Northern peatlands are globally significant carbon stores, but the sink strength may vary from year-to-year. In some years, peatlands may even be carbon sources due to variations in climatic conditions. Peatlands cover roughly 12% of Canada's terrestrial surface, thus future changes in climate (or land use) could have an impact on Canada's overall greenhouse gas emissions. Models can project the sensitivity of peatland carbon balance components to climate and land-use changes. However, most models partition ecosystem respiration into its autotrophic (respiration by plant parts) and heterotrophic (respiration by microbial bacteria in the soil) components using poorly known and constant ratios. This partitioning approach may lead to erroneous estimates if a change favours one form of respiration over another and alters allocations of carbon to labile pools with different turnover rates. Additionally, obtaining direct measurements is essential to explaining the temporal and spatial dynamics of respiration. The objective of this study is thus, to determine the factors that drive the spatial and temporal variability in respiration and its autotrophic and heterotrophic components at Mer Bleue, an ombrotrophic bog. Direct plot level measurements (manual chamber methods) were used to partition respiration, and the controls on respiration were explored by measuring a variety of environmental variables. Results show highest autotrophic respiration in cooler and wetter conditions and highest heterotrophic respiration in hotter and drier conditions, with the shrub species showing a higher variability in respiration than the sedge species. Furthermore, when the site is exposed to hot and dry conditions, the vascular plants seem to be inhibiting the decomposition of the microbes below. This project will improve our understanding of peatland carbon cycling as well as improve the parameterization of current peatland models.

Convenors: Catherine Champagne (lead convenor), Shannon Brown, Aston Chipanshi, Elizabeth Pattey, Ward Smith, Alexander Moravek

This session focuses on (1) understanding relationships between climate and land based resource sectors such as agriculture, forestry and water in order to ensure the resiliency of these sectors, as well as (2) measuring and simulating the impact of land-atmosphere interactions in a changing world.
We invite contributions (1) that expand our knowledge base on how we can use past, present and future climates to better adapt and reduce costs associated with climate change, variability and extreme events and (2) that improve our understanding on land-atmosphere exchange. We encourage submissions related (but not limited to) any of the following sub-themes:

1. Exploring productivity limitations under different climatic regimes.
2. Integrating climate extremes in ecosystem models.
3. Mainstreaming climate information in resource based sectors.
4. Trend, magnitude, frequency and severity analysis of sector specific climate indices under the past, present and future climate scenarios.
5. Empirical/process-based methods for estimating climate variability impacts on ecosystems across multiple spatio-temporal scales.
6. Translating weather forecasts into useful decision support tools for natural resource managers.

7. Remote sensing applications in land surface meteorology, agriculture and forestry.
8. Measurements of land-atmosphere exchange of energy, water, particles, greenhouse gases and other atmospheric pollutants.

9. Ecosystem models and land surface schemes exploring biophysical and biogeochemical processes underlying land-atmosphere interactions.
10. Methodological guidelines and standards for measuring and simulating land-atmosphere exchange.

Session: 2010111 Land, Agriculture and Climate - Part 2 Terre, agriculture et climat - Partie 2

27/05/2020 13:05

ID: 10249 Contributed abstract

Western Canadian Freshwater Availability: Current and Future Vulnerabilities

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Presented by / Présenté par: ***Barrie Bonsal***
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The western cordillera of Canada supplies freshwater across much of western Canada mainly through meltwater from snow and ice. This “alpine water tower” has, and is projected to continue to be associated with changes in the seasonality and amount of freshwater availability, which is critical in supporting the environmental flow needs of the region. This study identifies and synthesizes current and projected future freshwater supplies and demands across major north, west, and east flowing sub-basins of the Canadian western cordillera. The assessment of supply indicators reveals several historical changes that are projected to continue and be exacerbated, particularly at the end of this century and under higher greenhouse gas emission scenarios. The greatest and most widespread change is in the seasonality of streamflow characterized by earlier spring freshets, increased winter, and decreased summer flow. Future projections reveal that north flowing rivers will experience the greatest warming and increases in precipitation. West and east flowing rivers show less overall warming with smaller annual precipitation increases and in many cases, summer decreases. Future winter and spring warming over all basins will result in decreases in snow water equivalent with highest percentages in more southern regions. In many areas, there will be a greater likelihood of summer freshwater shortages. All sub-basins have environmental and economic freshwater demands/pressures, especially in more southern watersheds where population and human built infrastructure are most prevalent. Of particular concern are suitable aquatic habitat, water quality, as well as, industrial, agricultural, and energy needs. The aforementioned hydro -climatic changes along with continued/increasing demands will combine to create numerous freshwater vulnerabilities across all regions of western Canada. These vulnerabilities will require various adaptation measures in response to alterations in the timing and amount of future freshwater supplies and demands.

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27/05/2020 13:17

ID: 10548 Contributed abstract

Historical Rainfall and Runoff Analysis and Climate Implications for Agriculture in the Midwest United States

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Presented by / Présenté par: ***Jane Niemeyer***
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An historical analysis of precipitation using a 72 year dataset from Midwest stations focuses on the implications of climate change for agricultural interests. The number of precipitation events, consecutive days of precipitation and the variability of the precipitation is included. Future climate scenarios using the Climate Model Intercomparison Project (CMIP) are analyzed also, by comparing the most recent observations with model simulations. Although increased precipitation can be beneficial for the agricultural industry and economics of the Midwest, excessive rainfall events lead to runoff, which does not improve soil water content and plant available water. In order to examine the beneficial nature of rainfall events in the Midwest, rainfall retention is estimated using the United States Department of Agriculture Soil Conservation Service (USDA-NRCS/SCS) method. This method can be described briefly as an empirical formula estimating the soil's ability to store water and the amount of runoff. It was found that not only has rainfall increased but so have the number of rainfall days and the number of consecutive days of rainfall. In order to apply the findings to an agricultural focus, spring and fall rainfall days were also found to increase implying that farmers may have less days to complete fieldwork in the current climate. With increasing precipitation, the potential for runoff also increases, losing valuable water needed for crops and contributing to lost nutrients in the soil. Future simulations provide mixed results for our region with northern regions expecting increased precipitation and runoff issues.

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27/05/2020 13:30

ID: 10420 Contributed abstract

An improved crop precipitation deficit indicator for corn yield prediction, using STICS crop model in eastern Canada

Morteza Mesbah [1] , *Elizabeth Pattey* [2] , *Guillaume Jégo* [3] , *Catherine Champagne* [4]

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Presented by / Présenté par: ***Elizabeth Pattey***
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More than 90% of grain corn production in Canada is cultivated in the ecozone extending from south western Ontario and to western Quebec. The ecozone has a significant agroclimatic gradient, for both growing season precipitations and crop heat units. Inter-annual variability in precipitation and its uneven distribution may lead to water shortage during the growing season, which in turn may cause crop yield reduction. While cumulative precipitation is a key climate factor representing crop growth, it does not account for crop temporal need for water, especially in rainfall deficit years. Neither does it represent soil water holding capacity, a key component relating water availability to yield. We propose a new precipitation deficit indicator, named “growing season weighted precipitation”, to better predict corn yield where rainfall deficit are observed. We used STICS crop model adapted for corn cultivars in eastern Canada with good performance in predicting shoot biomass, and yield. Simulations were performed in five regions along the ecozone for the three most contrasting and dominant soil textures for 50+ years. Measured eddy covariance evapotranspiration fluxes in Ottawa area during several growing seasons were used to verify the good model performance in predicting daily evapotranspiration. The new indicator was then calculated by integrating modeled evapotranspiration and daily precipitation within 10-day intervals for given soil and climate. Transfer of water between 10 day intervals was also optimized to better represent the yield response. Our results indicated that in central and northwest regions of the ecozone, the new indicator lead to marginal improvement in yield prediction due to limited rainfall deficit, while deficit in crop heat units are more often observed. However, in southwest regions where there was more frequent rainfall deficit, the new indicator was able to better predict yield and improve the linearity with yield for all dominant soil textures.

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27/05/2020 13:42

ID: 10298 Contributed abstract

Evaluation of Satellite-derived Soil Moisture Products over Agricultural Regions of Canada

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Presented by / Présenté par: ***Yaasiin Oozeer***
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Soil moisture is a critical indicator for climate change and agricultural drought, but its measurement is

challenging due to large variability with land cover, soil type, time, space and depth. Satellite estimates of soil moisture are highly desirable and have become more widely available over the past decade. This study investigates and compares the performance of four surface soil moisture satellite datasets over Canada, namely, Soil Moisture Ocean Salinity Level 3 (SMOS L3), versions 3.3 and 4.2 of European Space Agency Climate Change Initiative (ESA CCI) soil moisture product, and a recent product called SMOS-INRA-CESBIO (SMOS-IC) that contains corrections designed to reduce several known sources of uncertainty in SMOS L3. These datasets were evaluated against in situ networks located in mostly agricultural regions of Canada for the period 2012 to 2014. Two statistical comparison methods were used, namely, Metrics for mean soil moisture and Median of metrics. The results show that, while both methods show similar comparisons for regional networks, over large networks, the median of metrics method is more representative of the overall correlation and variability and is therefore a more appropriate method for evaluating the performance of satellite products. Overall, the SMOS products have higher daily temporal correlations, but larger biases, against in situ soil moisture than the ESA CCI products, with SMOS-IC having higher correlations and smaller variability than SMOS L3. The results also show that the SMOS products capture wetting and drying events better than the ESA CCI products, with SMOS capturing an average of 78% of observed drying as compared to 67% for ESA CCI. Overall, for periods during which there are sufficient observations, both SMOS products are more suitable for agricultural applications over Canada than the ESA CCI products, even though SMOS-IC is able to capture SM variability more accurately than SMOS L3.

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27/05/2020 13:55

ID: 10421 Contributed abstract

Impact of Climatic Data Spatial Resolution on Soil properties and Management Practices Estimation using the STICS Crop Model in Eastern Canada

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Presented by / Présenté par: ***Sameh Saadi***
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Regional crop yield prediction is of paramount importance to national food security assessment. The

precision of yield prediction depends heavily on the availability and accuracy of information about climate, management practices and soil properties. Despite their importance in water and nutrient cycling, soil properties are often not sufficiently considered in regional scale crop modeling; most soil properties are available locally from soil cores, which need to be interpolated over large areas.

The assimilation of Earth observation (EO) data into crop models has proven to be an efficient way to improve yield prediction at a regional scale by re-initialization and optimization of key unknown crop management practices and soil physical properties. In this study, we evaluated the performance of the STICS, (Simulateur mulTIdisciplinaire pour les Cultures Standard; Brisson et al., 1998), a functional crop model, in re-initializing seeding date and soil moisture at field capacity, using Leaf Area Index (LAI) retrieved from EO data, over three growing seasons (2017–2019) for rainfed corn, soybean and spring wheat fields cultivated in Ottawa area, Ontario, Canada (45o 18' N, 75o 45' W). Green LAI was estimated using Sentinel-2 satellite data, estimated using a neural network approach (Delloye et al., 2018). Re -initialization of the model parameters used the STICS simplex optimization algorithm to minimize the weighted sum-of-squared differences between EO-retrieved LAI and crop model-predicted LAI. Previous results in Eastern Canada (Jégo et al., 2015) highlight the importance of using fine-resolution gridded daily precipitation data to capture spatial variation of rainfall. In this study the re-initialization of seeding date and soil moisture at field capacity was evaluated under different scenarios. The scenarios were designed to examine the impact of using precipitation data derived from i) one centrally located weather station, ii) a rain gauge network covering the area and iii) gridded weather data (beta version at 2.5 km spatial resolution) provided by Environment and Climate Change Canada across the region of interest. The evaluation of the optimized model parameters was performed through the comparison of optimized seeding date with observed data collected in the studied fields, and optimized soil moisture at field capacity with values calculated from soil textural classes using pedotransfer functions (Saxton et al., 1986).

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27/05/2020 14:07

ID: 10438 Contributed abstract

Application of a gap-filling routine to improve seasonal and annual ET measurements from weighing lysimeters

Shannon E Brown [1] , *Claudia Wagner-Riddle* [2] , *Aaron Berg* [3] , *Peter Isaac* [4]

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Presented by / Présenté par: ***Shannon E Brown***
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Large weighing soil lysimeters are considered the best means for precise water flux measurements under field conditions. A facility consisting of 18 high-precision weighing lysimeters was installed in Elora, Ontario, Canada, to examine the impacts of diversified crop rotations in combination with artificial

winter warming on agri-environmental factors such as nutrient leaching, GHG emissions, and water use. The weighing lysimeters provide long-term, continuous, high-frequency measurements of water budget components from three treatments – conventional annuals, diversified annuals, and diversified annuals with winter heating for two different soil types. Data gaps occur periodically in the growing season due to maintenance and agronomic operations. Gaps are more prevalent during winter conditions from weather-related equipment malfunctions. Filling the time series using simple linear regression causes biases in the calculation of annual water losses via ET, thus generating uncertainty in evaluating the water use of the cropping systems, and alternative methods currently do not exist. Filling evaporation data in the winter is more complicated because the evaporation signal is confounded with losses from other means, such as blowing snow or runoff from intermittent thawing. Methods do not exist to extract the winter evaporation from lysimeter data. This study applied an algorithm to define winter evaporation measured by the lysimeters, and then applied an artificial neural network based ET gap-filling routine (PyFluxPro, Isaac et al. 2017) to complete the ET time series from the 18 lysimeters. This allowed for an assessment of the gap-filling routine on quantifications of seasonal and annual water losses.

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27/05/2020 14:20

ID: 10485 Contributed abstract

Application of the Vegetation Drought Response Index to Agricultural Regions in Canada

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Presented by / Présenté par: ***Tyler Black***
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Excessive moisture and droughts constitute a significant risk to agricultural production across Canada. The Vegetative Drought Response Index (VegDRI) models the vegetative stress in response to moisture conditions across the country. VegDRI maps are produced every week during the agricultural growing season to assess the state of Canadian agricultural production. The model incorporates data derived from MODIS satellite earth observations, a 36-week Standardized Precipitation Index (SPI) calculation from weather stations across Canada, and relatively static inputs such as ecoregion and soil available water holding capacity. We calculate vegetative stress in two ways: Percent Annual Seasonal Greenness (PASG) and Start of Seasonal Anomaly (SOSA). PASG is a measure of the current seasonal greenness compared to the historical average seasonal greenness (2000-2014). SOSA is a calculation of the date that vegetation begins to green up compared to local average dates. These data are captured and modelled weekly to provide a snapshot of vegetative stress in agriculture during the growing season, as a result of moisture levels across the country. The goal of the project is to develop a

robust methodology and tool for producers, researchers, and policy-makers that can assist with assessing current and long term climate-related agricultural production risks. Future tasks consist of adding new weather datasets to the model and recalibrating the model to accommodate more modern satellite imagery.

Convenors: Catherine Champagne (lead convenor), Shannon Brown, Aston Chipanshi, Elizabeth Pattey, Ward Smith, Alexander Moravek

This session focuses on (1) understanding relationships between climate and land based resource sectors such as agriculture, forestry and water in order to ensure the resiliency of these sectors, as well as (2) measuring and simulating the impact of land-atmosphere interactions in a changing world.
We invite contributions (1) that expand our knowledge base on how we can use past, present and future climates to better adapt and reduce costs associated with climate change, variability and extreme events and (2) that improve our understanding on land-atmosphere exchange. We encourage submissions related (but not limited to) any of the following sub-themes:

1. Exploring productivity limitations under different climatic regimes.
2. Integrating climate extremes in ecosystem models.
3. Mainstreaming climate information in resource based sectors.
4. Trend, magnitude, frequency and severity analysis of sector specific climate indices under the past, present and future climate scenarios.
5. Empirical/process-based methods for estimating climate variability impacts on ecosystems across multiple spatio-temporal scales.
6. Translating weather forecasts into useful decision support tools for natural resource managers.
7. Remote sensing applications in land surface meteorology, agriculture and forestry.
8. Measurements of land-atmosphere exchange of energy, water, particles, greenhouse gases and other atmospheric pollutants.

9. Ecosystem models and land surface schemes exploring biophysical and biogeochemical processes underlying land-atmosphere interactions.
10. Methodological guidelines and standards for measuring and simulating land-atmosphere exchange.

Session: 2010112 Land, Agriculture and Climate - Part 3 Terre, agriculture et climat - Partie 3

27/05/2020 15:05

ID: 10235 Contributed abstract

Thousand year history of disturbance and climate impacts on forests of southeastern Canada

Konrad Gajewski [1]

[1] University of Ottawa

Presented by / Présenté par: ***Konrad Gajewski***
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Our understanding of climate change impacts on forests is based on less than a century of study in a disturbed landscape. As a consequence, knowledge about the effects of climate variability on forest dynamics and disturbance regime are not necessarily representative of longer-term “natural” interactions. Paleoecological analyses provide a long-term record of climate impacts on forests which

provides a context for the current warming. Sediment cores from southeastern Canada, dated using varves or radiocarbon and typically analyzed at 10-30 year resolution, document changes in forest composition and production for the past 1000 years. Century-scale climate variability, such as the Little Ice Age (CE 1450-1850) and Medieval Warm Period (~CE800-1300) changed the composition of the forests, and the data also show the interaction of climate and fire disturbance on the forest response. The impacts of Indigenous agriculture on the forests has been identified in areas with high concentrations of population, so the forests encountered by the first European settlers were already affected by human activity. These studies show the impacts of both climate and disturbance on the forests. The impact of European settlement, including fires and agriculture, as well as changes in the forests due to recent climate change can be put into a longer-term context using these paleoecological results.

Session: 2010112 Land, Agriculture and Climate - Part 3 Terre, agriculture et climat - Partie 3

27/05/2020 15:17

ID: 10317 Contributed abstract

Benchmarking land surface models

Christian Seiler [1]

[1] Environment and Climate Change Canada

Presented by / Présenté par: ***Christian Seiler***
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The increasing complexity of land surface models paired with the increasing availability of global earth observations creates the demand for more advanced methods of model evaluation. This presentation assesses the carbon, energy, and water cycle simulated by the Canadian Land Surface Scheme Including Biogeochemical Cycles (CLASSIC). The evaluation is based on a skill score system that summarizes model performance across multiple statistical metrics and a wide range of observations from satellite imagery, eddy covariance data, and streamflow measurements. Results show that, while CLASSIC performs reasonably well, the model overestimates biomass and leaf area index, which causes positive biases in ecosystem respiration and net ecosystem exchange. Furthermore, the model tends to overestimate snow water equivalent, which leads to positive biases in surface albedo and small negative biases in net surface radiation. The framework produces a performance matrix that serves as a baseline for assessing how model development affects model performance. Future research on land surface model evaluation would greatly benefit from a centralized global earth observation database that incorporates observational uncertainties.

Session: 2010112 Land, Agriculture and Climate - Part 3 Terre, agriculture et climat - Partie 3

27/05/2020 15:30

ID: 10409 Contributed abstract

Towards an improved methodology for modelling climate change impacts on cropping systems

Ward Smith [1] , *Brian Grant* [2] , *Zhiming Qi* [3] , *Wentian He* [4] , *Budong Qian* [5] , *Qi Jing* [6] , *Andrew VanderZaag* [7] , *Craig Drury* [8] , *Mervin St Luce* [9] , *Claudia Wagner-Riddle* [10]

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Presented by / Présenté par: ***Ward Smith***
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Assessment of the impact of future climate change on agricultural sustainability requires a robust full system estimation of the interdependent soil-plant-atmospheric processes coupled with dynamic farm management. The simplification or exclusion of major feedback mechanisms in modelling approaches, such as Carbon (C) and Nitrogen (N) cycling, water and nutrient leaching, trace gas emissions and dynamic farm management, may significantly alter the final estimate. Using three case study locations in Canada and a validated full systems biogeochemical model, DNDC v.CAN, we quantified the impact of using commonly employed simplified modelling approaches to better understand their impact on the estimation of crop yields, soil organic carbon (SOC) change and N losses. These approaches included using climate with only temperature and precipitation data, annual re-initialization of soil status, fixed fertilizer application rates, and fixed planting dates. The simplified approaches were compared to a comprehensive reference approach that was employed using detailed climate drivers, dynamic planting dates, dynamic fertilizer rates, and continuous estimation of SOC, N and water budgets. We also explored alternative cultivars and rotational impacts. At the semi-arid location the fixed fertilizer, fixed planting date, and re-initialization approaches resulted in spring wheat (Triticum aestivum L.) yield estimates being reduced by 40, 25, and 29%, respectively, in the 2071-2100 period relative to the reference approach where yield estimates increased by 74% relative to the 2011-2040 period. Simulations with and without re-initialization of soil status demonstrated that long-term inter-annual feedbacks in C&N cycling sometimes significantly impacted crop yields, SOC levels and N losses. For all locations and approaches, there were significant differences in N losses relative to the reference approach. We conclude that simplified approaches often lack the necessary characterization of the feedbacks between climate, soil, crop and management that are critical for accurately assessing crop system behaviour under future climate.

ID: 10430 Contributed abstract

Improving Crop yield forecasting with spatial modelling at sub-regional scale under a changing climate

Aston Chipanshi [1] , *Bahram Daneshfar* [2] , *Heather McNairn* [3] , *Xianfeng Jiao* [4] , *Yinsuo Zhang* [5] , *Catherine Champagne* [6]

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Presented by / Présenté par: ***Aston Chipanshi***
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The objective of this presentation is to demonstrate the progress that Agriculture and Agri-Food Canada (AAFC) scientists have made towards predicting crop yield at finer scale for early warning purposes. At the regional (provincial) and national scales, the Canadian Crop Yield Forecaster (CCYF) model provides forecasts for 11 major crops across Canada with a 2 to 3 months lead time from climate and remote sensing variables. These forecasts compare favourably with crop yield values surveyed and published by Statistics Canada. Modeling units of the CCYF are Census Agricultural Areas (CAR) which are in essence administrative boundaries and covering very large areas. The scalability of these forecasts to smaller units, however remains challenging. In this study we tested the applicability of the CCYF model at smaller than CAR regions. Each smaller modeling unit was created by combining a group of townships (almost 10x10 km) that are located within each ecodistrict in which a target crop has been historically reported. Such modeling units therefore follow biophysical boundaries. The dependent variable (crop yield, Y) was the reported yield of the target crop at quarter section level (almost 800x800m) averaged by the township that contains the quarter section. Predictor variables included the MODIS derived Normalized Difference Vegetation Index (NDVI), raster-based soil moisture stress index from the Soil Moisture Ocean Salinity (SMOS),the model-based gridded 2.5x2.5 km temperature, the10x10 km gridded CaPA precipitation from the Canadian Meteorological Centre and the model-based 10x10 km Evaporative Stress Index (ESI). With only 5 years of model testing, we found a significant statistical relationship between the observed and predicted township scale canola yield (R2> 0.75) on the Canadian Prairies. We concluded that with spatial stratification, spatial modelling methods and careful selection of predictor variables, downscaling of regional yields to the local level is possible.

Session: 2010112 Land, Agriculture and Climate - Part 3 Terre, agriculture et climat - Partie 3

27/05/2020 15:55

ID: 10369 Contributed abstract

Testing of ensemble algorithms to improve the national crop yield forecasting with

multiple earth observation datasets

Yinsuo Zhang [1] , *Aston Chipanshi* [2] , *Catherine Champagne* [3] , *Bahram Daneshfar* [4]

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Presented by / Présenté par: ***Yinsuo Zhang***
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In collaboration with Statistics Canada (STC), scientists from Agriculture and Agri-Food Canada (AAFC) have developed a crop yield forecasting method, i.e. the Canadian Crop Yield Forecaster (CCYF), to provide in-season or shortly after season yield and production outlook for major Canadian crops. The current operational model is primarily driven by weather information from climate stations and the Normalized Difference Vegetation Index (NDVI) from satellite platforms. While these two sets of data provide robust prediction for most crops across Canada, there are pockets of regions where prediction accuracy is weaker and require a broader range of predictors than is traditionally used. Previous tests with newer sources of Earth Observation (EO) derived variables, such as an evaporative stress index (ESI) and the satellite soil moisture (SSM) from active and passive microwave data provided some improvement in the forecast skill for some crops from parts of Canada, but did not achieve an overall improvement for all crops across all regions. In this study, we tested five ensemble algorithms for yield forecasts with multiple EO datasets, in order to achieve an overall improvement over any single or combination of EO datasets used. The preliminary results showed that carefully selected ensemble algorithms with new EO data sources improved the national yield forecasting accuracy by 1-2% compared to the current operational forecast.

Session: 2010112 Land, Agriculture and Climate - Part 3 Terre, agriculture et climat - Partie 3

27/05/2020 16:07

ID: 10233 Contributed abstract

Global land in-situ-based temperature and precipitation extremes of relevance to agriculture from HadEX3: 1901 - 2018

Jim Salinger [1] , *Robert Dunn* [2] , *Lisa Alexander* [3] , *Markus Donat* [4]

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[2] United Kingdom Meteorological Office
[3] University of New South Wales, Australia
[4] Barceloan Supercomputing Centre, Spain

Presented by / Présenté par: ***Jim Salinger***
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We present the second update to a dataset of gridded land-based temperature and precipitation extremes indices: HadEX3. This consists of 17 temperature and 12 precipitation indices that are derived from daily, in-situ observations and which have been recommended by the Commission for Climatology Expert Team on Climate Change Detection and Indices (ETCCDI). These indices have been calculated at around 8000 locations for temperature and 16000 for precipitation. The annual indices 67 have been interpolated on a 1:875° X 1:25° by longitude-latitude grid, covering 1901-2018. We show changes in these indices by examining global -average timeseries in comparison with previous observational datasets, and estimating the uncertainty resulting from the non-uniform distribution of meteorological stations. Trends and variability in agricultural important indices will include growing season length, ice days, frost days, summer days, warm spell duration index, cold spell duration index, consecutive dry days and consecutive wet days. Both the short and long timescale behaviour of HadEX3 agrees well with existing products. Changes in the temperature indices of agricultural importance are widespread and consistent with global-scale warming. The extremes related to daily minimum temperatures are changing faster than the maximum. Spatial changes in the linear trends of precipitation indices with agricultural relevance over 1951-2018 are less homogeneous than those for temperature indices. Globally, the fraction of precipitation falling in heavy events has increased. Trends and variability will be described for agriculturally significant land masses.

Day 3 - 28 May 2020

Convenors: Hai Lin, Bin Yu

This session invites contributions that deal with climate variability and predictions on subseasonal, seasonal, interannual and decadal-interdecadal time scales. Contributions are solicited on topics including studies of the Madden-Julian Oscillation (MJO) and tropical waves, El Nino/Southern Oscillation (ENSO), atmospheric circulation patterns, tropical-extratropical interaction and teleconnections, and impacts of these processes on predictability and predictions. Equally welcome are contributions on extended- and long-range weather forecasts, and predictions of climate variability on various time scales, including ensemble and initialization techniques, model development, forecast skill assessment, downscaling and calibration, and end-user value and applications. Results from diagnostic, modelling, model inter-comparison, and theoretical approaches are all welcome.

Session: 2010130 Climate Variability and Predictability - Part 1 La variabilité et la prévisibilité du climat - Partie 1 — 28/05/2020 11:00

ID: 10279 Invited session speaker

Predictability in Short and Long Range Forecasting: The Utility of Integrated Enstrophy in Detecting Flow Regime Transitions Across the Northern Hemisphere

Anthony Lupo [1]

[1] University of Missouri

Presented by / Présenté par: ***Anthony Lupo***
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Integrated regional enstrophy (IRE) is the enstrophy integrated over the entire Northern Hemisphere

or a large-subsection at a specific atmospheric level (usually 500 hPa). Previous work has shown this quantity is correlated to the positive Lyapunov Exponent for hemispheric flow, or Kolmogorov-Sinai Entropy, and as such is a measure of flow stability or predictability. Studies have demonstrated that IRE is useful also in detecting flow regime transitions and the onset and decay of blocking anticyclones. The results of several studies using this quantity are summarized here, including a one-year analysis of ensemble forecasts for the central USA. The data sets used were the 500 hPa initial and forecast fields for the Global Ensemble Forecasting System (GEFS) (on a 1o x 1o latitude-longitude grid) provided by the National Oceanic and Atmospheric Administration (NOAA) Weather Prediction Center (WPC) and the National Centers for Environmental Prediction / NOAA reanalyses (on a 2.5o x 2.5o latitude-longitude grid) archived in Boulder, CO. The GEFS forecast fields were provided every 24-h out to 240-h. By examining these forecasts over a year, we have found that significant changes in IRE values are a good predictor of flow regime transition as much as 10 days in advance, and several cases were found that involved abrupt changes in the weather over central and eastern North America. These abrupt changes correlate strongly to changes in the major North American teleconnection indexes. We also found that the IRE forecasts identified these regime transitions reliably out to four days, and the skill decreased significantly after this time. Additionally, a threshold for changes in IRE was found for the cases studied here and this varied by season.

Session: 2010130 Climate Variability and Predictability - Part 1 La variabilité et la prévisibilité du climat - Partie 1

28/05/2020 11:30

ID: 10464 Contributed abstract

Tropically forcing the Circumglobal Teleconnection pattern

Nicholas Soulard [1] , *Hai Lin* [2] , *Jacques Derome* [3] , *Bin Yu* [4]

[1] McGill University
[2] Environment and Climate Change Canada
[3] McGill University
[4] Environment and Climate Change Canada

Presented by / Présenté par: ***Nicholas Soulard***
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Recently there has been an increase in interest in hemispheric-scale teleconnections. In 2002 Branstator showed that there was no preferred meridional phase of variability within the South Asian Jet Stream, but one phase was special. When the Jet is in this particular meridional phase, there exists a circumglobal teleconnection (CGT) whereby disturbances originating near the Jet entrance, or within the Jet, remain trapped and can propagate around most of the globe. Recent studies have shown that this CGT pattern is associated with convection in the vicinity of India, and due to its scale, affects climatic conditions across the entire hemisphere, from North America to Europe to South Asia. The CGT is generally assumed to be a mode of variability internal to the atmosphere, but this study aims to find if the CGT can be forced to occur during the winter when the Jet is at its peak amplitude. We make use of a simple general circulation model to test whether an imposed diabatic heating anomaly in the tropics can force the CGT.
Results from the simple GCM show that a forcing in the Indian and western Tropical Pacific oceans, can

drive a CGT-like pattern. However, verification using reanalysis data shows that only convection in the Indian Ocean reliably precedes the CGT.

Session: 2010130 Climate Variability and Predictability - Part 1 La variabilité et la prévisibilité du climat - Partie 1 28/05/2020 11:45

ID: 10237 Contributed abstract

Primary Drivers of Marine Heatwaves in the Northwest Atlantic

Robert Schlegel [1] , *Ke Chen* [2] , *Eric Oliver* [3]

[1] OFI
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[3] Dalhousie

Presented by / Présenté par: ***Robert Schlegel***
Contact: robert.schlegel@dal.ca

As the frequency and intensity of marine heatwaves (MHWs) around the world is increasing, it is becoming more important that techniques for rapidly inferring the physical drivers of MHWs be developed and implemented. We show here the efficacy of an already tested technique, self-organising maps (SOM), for the detection of the primary drivers of hundreds of historic MHWs recorded in the shelf regions of the Northwest Atlantic Ocean. The SOM is given mean synoptic states of several important mixed-layer heat budget variables over the study area during the occurrence of all recorded MHWs over the 1993 – 2018 period. The output of the SOM is then interpreted as a typology of MHW events, and used to deduce what the primary drivers of each MHW type in this region are. The three primary patterns associated with MHWs were a Gulf Stream related warm slope water and air temperature anomaly pushing up from the South, warm air sitting still over the study area for an abnormally long time, and warm easterly air anomalies pushing into the study area. Furthermore, the occurrence of MHWs was usually associated with a clear cyclonic storm system or anticyclonic blocking pattern. The importance of these patterns, as well as the smaller patterns observed are discussed. Advice on the implementation of this technique at an operational level is also provided.

Session: 2010130 Climate Variability and Predictability - Part 1 La variabilité et la prévisibilité du climat - Partie 1 28/05/2020 12:00

ID: 10570 Contributed abstract

Snow Distribution over Canada

Hong Lin [1] , *Christopher Hampel* [2] , *Lee Cudlip* [3]

[1] Environment and Climate Change Canada
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Presented by / Présenté par: ***Hong Lin***
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Snow is an important weather element for regional climate and hydrological applications in Canada. Environment and Climate Change Canada (ECCC) has been collecting and archiving snow data since 1954.
This study investigates the characteristic of historical snow on the ground measurement across Canada. Data from ECCC's national archive in the period from 1981 to 2010 are used in the analysis including the extreme and mean daily snow depth measurements. Detailed seasonal snow depth distributions from each Canadian provinces and territories were analyzed. The analysis were further grouped into about 100 smaller climate zones across Canada, the results will be presented and discussed.
In this presentation, we will also provide a briefly introduction on Meteorological Service of Canada's Data Management System and the real time snow depth data quality assessment for this system.

not presented

Session: 2010131 Climate Variability and Predictability - Part 2 La variabilité et la prévisibilité du climat -Partie 2 28/05/2020 13:00

ID: 10436 Contributed abstract

Forecasting Regional Arctic Sea Ice from a Month to Seasons (FRAMS)

Arlan Dirkson [1], *Bertrand Denis* [2], *William Merryfield* [3], *Adrienne Tivy* [4], *Bruno Tremblay* [5], *Christopher Bone* [6]

[1] Universite du Quebec a Montreal
[2] Canadian Centre for Meteorological and Environmental Prediction
[3] Canadian Centre for Climate Modelling and Analysis
[4] Canadian Ice Service
[5] McGill University
[6] University of Victoria

Presented by / Présenté par: ***Arlan Dirkson***
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This presentation provides an overview and status update of the FRAMS project, which is currently in its 3rd year. The objective of FRAMS is to establish a capacity to provide improved seasonal sea ice forecasts, in coordination with current capabilities at Environment and Climate Change Canada's Meteorological Service of Canada (MSC) and Canadian Ice Service (CIS), and within the framework of Canada's role in support of the World Meteorological Organization's (WMO's) new Arctic Regional Climate Centre (ArcRCC). In order to facilitate this objective, FRAMS activities are directed toward synergizing (1) the development of multi-model sea-ice forecast products using current operational WMO Global Producing Centre climate prediction systems; (2) the use of observations and seasonal prediction systems to investigate physical processes that enable skillful sea ice prediction; and (3) a

dialogue between FRAMS researchers and prospective forecast end users to guide the development of sea-ice forecast products. We present on the progress made regarding each of these three components, and also highlight the goals we hope to achieve in the final stages of the project.

Session: 2010131 Climate Variability and Predictability - Part 2 La variabilité et la prévisibilité du climat -Partie 2 28/05/2020 13:15

ID: 10388 Contributed abstract

Medium range sea ice presence forecasting using deep learning

Philippe Lamontagne [1]

[1] National Research Council Canada

Presented by / Présenté par: ***Philippe Lamontagne***
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In this presentation, we introduce prediction tools to forecast the probability of sea ice and lake ice presence up to 90 days in advance, to support safe and efficient shipping operations. This project utilizes machine learning deep neural networks to automatically combine short-term deterministic processes, yearly anomalies and climate normals to produce an enhanced unified forecast product of ice presence probability.
The ECMWF -ERA5 climate reanalysis dataset is used for training from 1985 to 2017. The general machine learning model architecture is a sequence -to-sequence model with intermittent high-dimensional representation and as such may be classified as an encoder-decoder paradigm. The raw model output is a sequence of daily gridded rasters representing the probability of sea-ice presence, at the same spatial resolution as the training dataset (0.25 degree).
A robust k-fold cross validation framework is used, due to the spatiotemporal variability and predictability of sea ice conditions. It includes binary accuracy maps and reliability diagrams as a function of the month and lead time. Derived break -up and freeze -up dates accuracy maps within 7 days and correlation maps between observed and forecasted break-up and freeze-up dates is also measured as a function of the lead time.
In this study, deep neural networks were trained for the Canadian Western Arctic, Eastern Arctic and Hudson Bay areas with noteworthy results. As an example, the model for Hudson Bay achieved a binary accuracy score of 0.90 for the month of November at 60-day lead time, 0.07 points above the climate normal. The model outperformed the climate normal mostly in the western part of Hudson Bay where there is a greater sea -ice presence variability for the month of November, with a binary accuracy improvement > 0.15. Finally, the skill of the forecasted break-up dates at 29 lead days were analyzed for Churchill port (r=0.93) and Kuujjuarapik (r=0.85).

Session: 2010131 Climate Variability and Predictability - Part 2 La variabilité et la prévisibilité du climat -Partie 2 28/05/2020 13:30

ID: 10531 Contributed abstract

Tuned seasonal weather prediction for South-West Ontario

Anuj Thapa [1] , *Khalid Malik* [2] , *Peter Taylor* [3]

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[3] CRESS, York University

Presented by / Présenté par: ***Anuj Thapa***
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Ocean and Atmospheric Coupled Global Climate Models (CGCMs) have been widely used to provide more accurate and coherent seasonal forecasts. However, they still show some limitations. Model Output Statistics approaches may improve performance if observed and forecast values are available for a long record. This study assessed the skill of ECHAM4p5 in simulating rainfall and temperature on a seasonal time scale over the Southwest Ontario region. Presently, the ECHAM4p5 model is run by the Foundation Cearense for Meteorology and Water Management (FUNCEME), Brazil. The model is run at the beginning of every month based on persisted SST from 0000 of 1st day of that month. The model is used for six-month weather predictions ahead of the start date.
Historical model data were available from IRI, Columbia University and used together with GPCC rainfall data and average daily temperature obtained from the CRU at University of East Anglia. Ten years of daily forecasts for SW Ontario from the ECHAM4p5 model are used to develop regional correction factors (RCF) to help in improving the model seasonal forecast confidence level. The analog-based Model Output Statistics (MOS) technique is applied for the seasonal and regional bias corrections. Our focus has been on the first four months of the forecast and comparisons are made against METAR and other data for SW Ontario. The comparison of tuned data and observation has been made of three different size domains i.e. South-west Ontario, Ontario and Pakistan. The purpose of comparison of different domain is to see how the confidence level of tuned data varies with increasing domain size as well as in different regions in the globe. The results are encouraging and can improve the confidence level of seasonal prediction in small as well as large areas domains all over the globe. The work was performed under an NSERC Engage grant with Weather Innovations Network as the industrial partner.

Session: 2010131 Climate Variability and Predictability - Part 2 La variabilité et la prévisibilité du climat -Partie 2 28/05/2020 13:45

ID: 10389 Contributed abstract

Forecast Skill of the NAO in the Subseasonal-to-Seasonal Prediction Models

Pei-Ning Feng [1] , *Hai Lin* [2] , *Jacques Derome* [3] , *Timothy Merlis* [4]

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Presented by / Présenté par: ***Pei-Ning Feng***
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The prediction skill of the North Atlantic Oscillation (NAO) in boreal winter is assessed using the dataset of the WCRP/WWRP Subseasonal-to-Seasonal (S2S) prediction project with reforecast data from 10 S2S models. The impact of the quasi-biennial oscillation (QBO) and the Madden-Julian Oscillation on the NAO skill is analyzed. In general, the forecasts with initial conditions containing negative phase of the NAO, and the phase 7 of the MJO which is associated with the negative phase of the NAO tend to have the more skillful predictions than other phases, although the signal is modest in some models. For the easterly phase of the QBO which is connected to the Northern Annular Mode indirectly through the stratospheric sudden warming, there is still an agreement of a relatively higher skill in some models. Among the eight phases of active MJO in the initial condition, the phase 3-5 (phase 7-1) that are related to the occurrences of a positive (negative) NAO event also lead to a better NAO skill compared with other phases and the inactive MJO events.

According to the vertical resolution, the S2S models can be divided into high-top models corresponding to the better-resolved stratosphere and low-top models with lower resolutions in the stratosphere. For most high-top models, the prediction skill of the NAO is in general better than the low-top models and is more sensitive to the initial state of the QBO and MJO. To improve the NAO prediction on the subseasonal time scale, it is important to have a reasonable representation of the stratosphere and the tropical-extratropical teleconnections.

Session: 2010131 Climate Variability and Predictability - Part 2 La variabilité et la prévisibilité du climat -Partie 2 28/05/2020 14:00

ID: 10364 Contributed abstract

Subseasonal Forecast Skill over the Northern Polar Region in Boreal Winter

Hai Lin [1]

[1] Environment and Climate Change Canada

Presented by / Présenté par: ***Hai Lin***
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Pentad (five-day averaged) forecast skill over the Arctic region in boreal winter is evaluated for the subseasonal to seasonal prediction (S2S) systems from three operational centers: the European Centre for Medium-Range Weather Forecasts (ECMWF), the U.S. National Centers for Environmental Prediction (NCEP), and Environment and Climate Change Canada (ECCC). The results indicate that for a lead time longer than about 10 days the forecast skill of 2-meter air temperature and 500-hPa geopotential height in the Arctic area is low comparing to the tropical and middle latitude regions. The three S2S systems have comparable forecast skill in the Northern polar region. Relatively high skill is observed in the Arctic sector north of the Bering Strait in pentads 4-6. Possible sources of S2S predictability in the polar region are explored. The polar forecast skill is found to be dependent on the phase of the Arctic Oscillation (AO) in the initial condition, i.e., forecasts initialized with the negative AO are more skillful than those starting from the positive AO. This is likely due to the influence of the

stratospheric polar vortex. The tropical MJO is found to also influence the prediction skill in the polar region. Forecasts starting from MJO phases 6-7, which correspond to suppressed convection in the equatorial eastern Indian Ocean and enhanced convection in the tropical western Pacific, tend to be more skillful than those initialized from other MJO phases. To improve the polar prediction on the subseasonal time scale, it is important to have well represented stratosphere and tropical MJO and their associated teleconnections in the model.

Convenors: Dominique Brunet, Gabrielle Gascon, Eva Mekis

Despite advances in ground-based and remotely sensed monitoring instruments and technology, observing precipitations in the Arctic remains challenging because of the remoteness of observing sites and harsh environmental conditions in the region. In a changing climate, it is important to properly assess changes in precipitation patterns and their impact on the hydrological cycle, e.g. flood, drought, impact on agriculture and impact on ecosystems. This session intends to bring together scientists interested in classic and emerging methods for observing precipitations in the Arctic with hydrologists, climatologists and other precipitation data users. Subjects of interest include the use of remote sensing for measuring precipitation (ground and space-based, active or passive), measurement of solid precipitation and determination of precipitation type, deployment of surface precipitation sensors in the North, and analysis of precipitation data.

Session: 2010020 Precipitation Observations in the Arctic
L'observation des précipitations dans l'Arctique

28/05/2020
15:00

ID: 10496 Invited session speaker

Probabilistic precipitation estimation in data sparse environments

Martyn Clark [1] , *Guoqiang Tang* [2] , *Andrew Newman* [3]

[1] University of Saskatchewan Coldwater Lab
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Presented by / Présenté par: ***Martyn Clark***
Contact: martyn.clark@usask.ca

Spatial meteorological datasets (e.g., gridded observations) provide estimates of the historical space-time variability in meteorological conditions – these datasets are used as "truth" to downscale numerical weather prediction models and climate models, and are used as forcing for process-based hydrological models. Spatial meteorological datasets are typically produced by interpolating station data to a spatial grid, or by merging station data with simulations from atmospheric models. Such approaches can over-estimate the wet-day frequency (by combining information from wet and dry stations) and under-estimate precipitation extremes (by combining information from stations with variable precipitation intensity). Moreover, such approaches do not quantify the uncertainty in the spatial meteorological fields. There are also unique challenges in Canada caused by inadequacies in the station network—the station networks in the mountains are biased to lower elevations, and the station networks in northern latitudes are rather sparse.

In this presentation we will describe ensemble spatial meteorological datasets that include all of the forcing data required for process-based hydrological models (precipitation, temperature, wind speed, solar and longwave radiation, air pressure). The development includes (1) construction of serially-

complete quality-controlled station datasets; (2) methods to produce ensemble gridded estimates of daily meteorology from station data, and the application of our method to produce ensemble meteorological estimates across large geographical domains; (3) conditioning the daily ensemble on the climatological ensemble through the method of ensemble Climatological Aided Interpolation (eCAI); (4) characterizing uncertainty in precipitation under-catch during snowfall events; and (5) conditioning the ensemble spatial meteorological estimates on information from atmospheric model reanalyses and satellite data. The presentation will discuss probabilistic information content, methodological weaknesses, and research needs.

Session: 2010020 Precipitation Observations in the Arctic
L'observation des précipitations dans l'Arctique 28/05/2020 15:30

ID: 10565 Contributed abstract

A serially complete precipitation and temperature dataset in North America from 1979 to 2018

Guoqiang Tang [1] , *Martyn Clark* [2] , *Andrew Newman* [3] , *Andrew Wood* [4] , *Simon Papalexiou* [5] , *Vincent Vionnet* [6] , *Paul Whitfield* [7]

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[2] University of Saskatchewan Coldwater Lab
[3] National Center for Atmospheric Research
[4] National Center for Atmospheric Research
[5] Centre for Hydrology, University of Saskatchewan
[6] Environment and Climate Change Canada
[7] University of Saskatchewan Coldwater Lab

Presented by / Présenté par: ***Guoqiang Tang***
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Serially complete datasets (SCDs) are important to meteorological, climatological and hydrological studies, such as the production of retrospective gridded products, trend analysis, and climatologic index calculation. However, station records often contain missing values due to factors such as observer absence, instrumental failures and interrupted communication. Station records failing quality control tests such as outlier and homogeneity checks may not be reliable. In addition, many stations are only maintained over a relatively short period of time or portions of the year, resulting in data gaps that could affect the analysis of climate variability and trend. Presently, a SCD is not available for North America.
The objective of this study is to develop a SCD from 1979 to 2018 from station data, which consists of daily precipitation, minimum temperature (Tmin), and maximum temperature (Tmax) data for 32590 stations. Raw meteorological data were obtained from public sources, including Global Historical Climate Network Daily (GHCN-D), Global Surface Summary of the Day (GSOD), Environment and Climate Change Canada (ECCC), and a compiled station database in Mexico. Only stations with at least 8-year records were selected, which underwent location correction and were subjected to strict quality control. Outputs from three reanalysis products (ERA5, JRA-55, and MERRA-2) were used to estimate station records and as an assessment benchmark. To match station data, reanalysis

temperature outputs were downscaled using gridded temperature lapse rate, while reanalysis precipitation outputs were linearly interpolated. Infilling during the observation period and reconstruction beyond the observation periods were generated by combining estimates from 17 strategies that are based on quantile mapping, spatial interpolation, and machine learning. The gap infilling and reconstruction are addressed separately to avoid the overfitting of some strategies which rely on information from the target station.
The final SCD is demonstrated to preserve the accuracy and spatial correlation as the observations. The SCD series are closer to station observations than gridded estimates, i.e., precipitation, Tmin, Tmax, mean temperature and temperature range from ERA5, JRA-55, and MERRA-2, and precipitation from the Multi -Source Weighted -Ensemble Precipitation (MSWEP). The SCD can be used in applications that require either quality-controlled meteorological station observations or reconstructed long-term estimates for analysis of modelling.

Session: 2010020 Precipitation Observations in the Arctic
L'observation des précipitations dans l'Arctique 28/05/2020 15:45

ID: 10248 Contributed abstract

Bias-correction of gridded SWE products using CloudSat-CPR snowfall estimates

Fraser King [1] , *Christopher Fletcher* [2]

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Presented by / Présenté par: ***Fraser King***
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Terrestrial snow has profound impacts on Earth's global water and energy budget, water resource availability, snow albedo feedback and flooding in cold regions. The Arctic is a critical region for environmental monitoring in an era of global change, however the vast size and remote nature of the region present logistical and scientific challenges to measuring snow there. Radar backscatter measurements from the Cloud Profiling Radar (CPR) instrument---aboard the NASA satellite CloudSat---allow the retrieval of snowfall rates in high latitude regions. Our previous CloudSat validation at four heavily-instrumented Environment and Climate Change Canada (ECCC) weather stations throughout the Canadian Arctic shows that CloudSat-derived estimates of snow accumulation in this region are highly reliable, with strong monthly correlations above 0.5 and low RMSE (<10 mm SWE). Here, we generalize the CloudSat gridding technique used in our earlier work to the wider Northern Hemisphere at 1 degree resolution to evaluate a series of commonly -used gridded SWE products and identify periods where the monthly gridded melt and/or accumulation are statistically inconsistent with CloudSat-estimated snow accumulation. We identify 7962 inconsistent periods when comparing CloudSat with the Blended-4 gridded SWE product poleward of 60 degree N over the full CloudSat data record 2007-2015. Masking these anomalous periods in each grid cell in the Blended -4 gridded SWE products produces a new adjusted SWE product. The adjusted product exhibits a systematically negative bias during the fall season when compared with the original Blended-4, suggesting excess snow during the fall accumulation period. The RMSE of the adjusted SWE product is also improved when compared to monthly ECCC accumulation estimates. Insights gained from the comparisons between CloudSat and

other gridded SWE products provides new important observational perspectives of Arctic snow accumulation.

Session: 2010020 Precipitation Observations in the Arctic
L'observation des précipitations dans l'Arctique 28/05/2020 16:00

ID: 10473 Contributed abstract

Validation of the Global Precipitation Measurement IMERG Products in the Canadian Arctic

Ellen Eckert [1], *David Hudak* [2], *Stella Melo* [3], *Éva Mekis* [4], *Peter Rodriguez* [5], *Bo Zhao* [6], *Zen Mariani* [7], *Kimberly Strong* [8], *Kaley A. Walker* [9]

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[6] Hebei Province Meteorological Information Center, Shijiazhuang, Hebei, China
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Presented by / Présenté par: ***Ellen Eckert***
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Precipitation is a meteorological variable with high spatial and temporal variability. It plays a key role in the hydrological cycle and is crucial for water resource management, reanalyses and numerical weather prediction as well as navigation. Solid precipitation is a parameter of critical importance for Canada, particularly for northern latitudes where ground-based monitoring is sparse. Satellite measurements can potentially fill this gap in a cost-effective manner. This work presents our evaluation of the Global Precipitation Measurement mission and assesses its performance over the Canadian Arctic.
The Integrated Multi-satellitE Retrievals for GPM (IMERG) algorithm combines the Global Precipitation Measurement Core Observatory (GPM-CO) and various satellite-borne passive microwave sensors to estimate precipitation rate. IMERG features an early, a late and a final product with a latency of 4 hours, 14 hours and 2.5 months, respectively.

IMERG v5.2 and v06 are compared with precipitation measurements of a subset of ground-based stations from the Environment and Climate Change Canada (ECCC) climate station network. This is an important step on the way to improve satellite-based estimates of solid precipitation amounts.
Correlations of IMERG with ground-based measurements are noticeably lower during winter and spring which is potentially linked to passive microwave sensors struggling over snowy and icy surfaces. Our analysis shows that IMERG consistently detects more precipitation than the ground-based network. Undercatch of precipitation gauges due to wind is a known issue and the WMO Solid Precipitation Intercomparison Experiment (SPICE) (2012-2015) was conducted to examine this issue in detail. Wind-

related underestimation of precipitation amounts by the gauges offers a potential explanation for the differences found in our study.

Session: 2010020 Precipitation Observations in the Arctic
L'observation des précipitations dans l'Arctique 28/05/2020 16:15

ID: 10547 Contributed abstract

An Arctic-based far-infrared radiometer to study the Polar night atmospheric hydro-radiative cycle

Ludovick S.Pelletier [1] , *Zen Mariani* [2] , *Frédéric Dubuis* [3] , *Jean-Pierre Blanchet* [4]

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Presented by / Présenté par: ***Ludovick S.Pelletier***
Contact: ludovick.s.pelletier@gmail.com

During the Polar night, most of the Earth's radiative emission to space occurs at longer wavelengths in the Far InfraRed (FIR) ranging between 15 and 100 μm. The atmospheric radiative cooling rate in this spectral region is very sensitive to the concentration of atmospheric water vapour and cloud microphysical properties. While theoretical work has shown the added value of FIR measurements for the retrieval of the ice clouds' microphysical properties and water vapour profiles, there is currently few instruments performing spectrally-resolved measurements in the FIR domain.

The Far InfraRed Radiometer (FIRR) uses an array of uncooled microbolometers developed by the Institut National d'Optique (INO) to measure downwelling radiances in 8 spectral channels spanning from 8 – 50 μm with a radiometric resolution of 0.02 [W m-2 sr -1]. Two versions of the instrument have already been deployed in the Canadian Arctic. The first one was tested during winter 2016 at the ØPAL (zero altitude Pearl Auxiliary Laboratory) lab in Eureka, NU (80N, 85.9W) in collaboration with Canadian Network for Detection of Atmospheric Change (CANDAC). The second instrument has been operating since September 2018 in Iqaluit, NU (63.75N,68.52 W), at the Environment and Climate Change Canada Canadian Arctic Weather Science (CAWS) supersite. Observations from the FIRR will also be used for weather forecast model verification and process studies as part of the WMO's Year Of Polar Prediction (YOPP) project. In this study, an evaluation of the FIRR's retrieval of precipitable water and its ability to discriminate between precipitating and non-precipitating clouds, against alternate retrievals from collocated instruments, including an E-AERI, radars, lidars, and radiosondes, at both Arctic sites will be presented. This project aim at improving observation to better understand the hydro-radiative water cycle in the cold region of the atmosphere.

Convenors: Sébastien Biner, Dominique Paquin, Ouranos

Both solid (snow, hail, sleet) and mixed (rain on snow, freezing rain) precipitation can have significant impacts on Canadian society. Direct impacts, such as transport disruptions during snowstorms, freezing rain events, or hail damages, are clear and understandable. However, numerous indirect impacts, such as effects of changing snow density or weight during rain on snow events, or effects of decreasing snow cover on various processes, are possible but are more difficult to evaluate. Nonetheless, both types of impacts may see their frequency, intensity, location, and duration altered by climate change.
This session focuses on understanding current conditions, as well as the anticipated changes, in solid and mixed precipitation events, both in terms of their representation in climate models and in terms of their societal impacts. The aim is to improve the current state of knowledge of solid and mixed precipitation events, as well as help planning efforts necessary to build a more resilient society.
We therefore invite researchers having evaluated the ability of models to represent these phenomena to submit an abstract to this session. We would also extend invitations to studies having examined the repercussions of particular events on society in general (or for specific sectors). Lastly, presentations examining anticipated changes in these phenomena on Canadian territory and in their associated current and future adaptation methods are also welcome.

Session: 2010070 Actual climatology and anticipated changes in winter precipitation (solid, mixed and liquid) and hail and their impacts - Part 1
Climatologie présente et changements anticipés des précipitations hivernales (solides, mixtes et liquides) et de la grêle et leurs impacts - Partie 1

29/05/2020 11:00

ID: 10299 Contributed abstract

Winter Storms and Storm Severity in the Saint Lawrence Valley between 1742 and 2020

Victoria Slonosky [1] , *Renée Sieber* [2] , *Frederic Fabry* [3] , *Morgen Bertheussen* [4] , *Ateeque Siddique* [5] , *Boris Olkhovskiy* [6] , *Kevin Cloutier* [7] , *Liu Chenguang* [8] , *Emilie Power* [9]

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Presented by / Présenté par: ***Victoria Slonosky***
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Daily weather records for the St Lawrence Valley region exist on a continuous basis for over two centuries, and on a more fragmentary level back to the French regime. Using these records along with data from the McGill Observatory and modern synoptic observations, winter storms, freezing rain and blowing snow are analyzed using methods adapted to the different sources.
Analysis of the 18th and 19th century weather diaries compared with 20th and 21st century synoptic observations suggest a marked increase in freezing rain, and points to the importance of recovering weather observation data from historical sources to improve analysis methods and account for potential

under-reporting. Snowstorm days give similar ranges over the historical and modern periods, ranging from 2 to 45 days for Quebec City and from 1 to 44 days for Montreal. Inhomogeneities in blowing snow appear to have occurred in the very recent data (since 2014), making the long-term blowing snow record difficult to interpret.
A Winter Storm Severity Index (WSSI) was calibrated by consolidating both meteorological observations and social impacts as described in newspaper reports for Montreal between 2014 to 2019. The index was then applied to the McGill Observatory (DRAW - Data Rescue: Archives and Weather) data for Januaries between 1879-1884. Preliminary results show that the WSSI gives very comparable results when used on the 19th century DRAW data and recent synoptic data, confirming its validity as a tool to compare winter storms from these two different data types and time periods. Both the WSSI and historical records integrate the social impacts of winter weather in ways that can be similar, such as noting the effect on transport, and in ways which are historically and socially contingent, such as reporting school closures.

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29/05/2020 11:15

ID: 10517 Contributed abstract

On Environment and Climate Change Canada (ECCC) Radar Snowfall Rate Estimates

Peter A. Taylor [1] , *Diar Hassan* [2] , *George A. Isaac* [3]

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Presented by / Présenté par: ***Peter A. Taylor***
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ECCC public weather sites display radar images in winter with a scale indicating reflectivity values (Ze*) in dBZ) and related snowfall rates (R, cm/hr = SWE in mm/hr). They employ the Sekhon-Srivastava (S-S) algorithm to estimate Snow-Water Equivalent (SWE) precipitation rate, R in mm/h during the winter season before using a constant 10:1 Snow-Liquid Ratio for snowfall rates in cm/h. The algorithm applied is R = 0.0338 Z^0.452, where Z is the radar reflectivity, ∫N(D)D^6dD in mm^6m^-3. Sekhon and Srivastava computed Z with melted snowflake diameters, D.
ECCC measure values of |K|^2 Z and could estimate Z, and Z* = 10 log10 Z, in dB, from the radar return signals (where |K|^2 is the dielectric constant of the hydrometeors). During the winter season, ECCC reduce the reflectivity, Z*, by 6.5 dB to calculate an equivalent reflectivity factor (Ze*) to account for the lower value of the ice dielectric constant relative to water (-7.23 dB) and for ice/water density differences (+0.76 dB).
In rain Ze* = Z*. For snowfall however, Fabry (2015) states, “When these two effects (lower density and lower |K|^2) are combined, we find that snowflakes reflect slightly more radar energy than solid ice

particles of the same mass." We use this as a starting point and assume that the unadjusted Z values in snowfall would be appropriate for ice spheres with |Kice|^2 used as the dielectric constant and would include the adjustment needed for Z to match the S-S use of melted diameters.
The ECCC Ze* adjustment (-6.5 dB) corresponds to a decrease in Z by a factor 10^0.65 = 4.47. ECCC use Ze in the S-S algorithm given above to estimate snowfall rates. They should be using Z, without the 6.5 dBZ adjustment. Using these Z values as we propose, the snowfall rates would double (Increased by the factor 4.47^0.452 = 1.96).
Hassan et al (2017a,b) compared radar reflectivity data with surface measurements from Oakville, Pearson Airport and Mount Pearl and found ECCC snowfall rates low, by a factor of approximately 1/2. Snowfall rates in St John's on Jan 17/18, 2020 will be used to further illustrate the problem.

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29/05/2020 11:45

ID: 10545 Contributed abstract

Flow field and distribution of precipitation over Fortress Mountain, Alberta

Aurélie Desroches-Lapointe [1] , *Julie M. Thériault* [2] , *Zen Mariani* [3] , *Nicolas R. Leroux* [4]

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Presented by / Présenté par: ***Aurélie Desroches-Lapointe***
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Mountain snowpack is the primary source of fresh water to downstream communities and is a key element in the assessment of natural hazards, such as flooding and avalanches. The deposition of solid precipitation over the winters drives snowpack spatial heterogeneities at the surface. In complex terrain, the fine-scale deposition patterns is controlled by the interaction between falling particles and the surrounding flow field. This interaction depends on the microphysical characteristics of precipitation particles, such as their degree of riming, their size, and their aspect ratio, which directly influence their drag coefficients. Consequently, the likeliness of particles to follow the wind streamlines vary with hydrometeor type. This study aims to better characterize the spatial distribution of solid precipitation for different hydrometeor types and the associated wind-driven processes.

To address this, in-situ and remote sensing observations were collected at Fortress Mountain in the Canadian Rockies, Alberta, during the Storm and Precipitation Across the continental Divide Experiment (SPADE), that took place in May and June 2019. Precipitation particles were characterized using an optical disdrometer (Parsivel) and macrophotography of solid precipitations. In addition, a Micro Rain

Radar (MRR) and a Doppler Lidar were deployed at two different elevations (at the valley bottom 1591m and at 2076m) to measure precipitation layers and 3D wind fields above each site. During the 12 storms observed, most of the precipitations at the higher elevation fell as snow while mixed precipitation was observed in the valley. Preliminary results suggest a link between observed vertical motion and the type of weather system. For example, upward motion prior to precipitation events at Fortress top is associated to an upper level trough, leading to upslope flow and orographic precipitation. Overall, this study contributes to improve the understanding of fine-scale precipitation deposition processes in the Canadian Rockies to better prepare for extreme events.

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29/05/2020 12:00

ID: 10482 Contributed abstract

Freezing rain events impacting the province of New Brunswick, Canada

Julien Chartrand [1] , *Julie M. Thériault* [2]

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Presented by / Présenté par: ***Julien Chartrand***
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Every year, many winter storms affect the Maritime Provinces, bringing heavy precipitation and strong winds. Several of these storms can result in severe freezing rain accumulation in the province of New Brunswick (NB), Canada, causing significant impacts on many sectors of society. In collaboration with NB Power, freezing rain events that led to widespread power outages and damages to infrastructure have been identified. To analyse these events and better understand the links between meteorological conditions and power outages, high-resolution convection-permitting simulations at 4 km grid spacing over the continental US (Liu et al., 2017) were used. These were produced from 2000-2013 as well as, in pseudo global warm (PGW) mode that assumes a warmer climate. The local effects influencing the intensity and types of precipitation distribution during the storms were investigated. The results showed that the presence of the Appalachian Mountains in NB enhances the differential temperature advection associated with veering winds through the process of cold air damming, which favors the development of strong temperature inversion in the lower-levels. This leads to an increase of freezing rain amounts in southern NB. Also, the presence of small-scale mountain ranges in central NB and on the southern coast can trigger orographic enhancement of precipitation and local change in the surface precipitation type. In PGW, there is a decrease of freezing rain event occurrence in southern and eastern NB (coastal regions), while it increases in northwestern NB, especially for long events (>6 hours). Overall, this study contributes to a better understanding of meteorological factors leading extreme freezing rain amounts in NB and to better anticipate the impact of climate change on those storms.

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29/05/2020 12:15

ID: 10384 Contributed abstract

A Synthetic Blizzard Climatology for the Canadian Arctic

Curtis Mooney [1] , *William Burrows* [2]

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Presented by / Présenté par: ***Curtis Mooney***
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Blizzards are a common occurrence north of the treeline in the Canadian Arctic. They are a significant hazard for transportation, whether air or overland, and can be life threatening for anyone caught outside their community during such an event. Consequently, a climatology of these events is a useful resource. However, the paucity of observation sites in the Arctic, in particular inland from coasts, means that large areas of the region are underrepresented when a climatology is based on observations alone. A possible alternative is to build a “synthetic” climatology using numerical weather prediction data and a blizzard model. In this study, the Baggaley-Hanesiak blizzard forecast model, driven by meteorological data derived from the CFSR (Climate Forecast System Reanalysis) dataset, is used to build a 38-year blizzard climatology for the Canadian Arctic. Regional and seasonal characteristics are examined.

Session: 2010071 Actual climatology and anticipated changes in winter precipitation (solid, mixed and liquid) and hail and their impacts - Part 2
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29/05/2020 13:00

ID: 10361 Contributed abstract

Historical trends and future evolution of solid and liquid precipitation over Southern Québec

Alain Mailhot [1] , *Guillaume Talbot* [2]

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Presented by / Présenté par: ***Alain Mailhot***
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Canadian municipalities face major issues regarding management of snow volumes and maintenance of roadways during winter. For instance, major snow accumulation during the 2018-2019 winter in Quebec City have resulted in many snow dumps almost at full capacities by the end of winter. Also, mixed winter precipitation (e.g., snow flowed by rain and freezing conditions) represents a real challenge for municipalities in terms of road and sidewalk maintenance. Considering that climate change may have a huge impact on the frequency and intensities of snow accumulations and mixed precipitation events, it is therefore crucial to assess how these may change in future climate.
Results from a study looking at monthly and seasonal changes in solid and liquid precipitation in future climate over Southern Québec will be presented. Various indices related to mixed precipitation, defined in collaboration with the service in charge of the road maintenance in Quebec City, will also been considered (e.g., annual number of days with solid and liquid precipitation).
First results of trend analysis based on daily records at stations operated by Environment and Climate Change Canada (ECCC), Ministère de l'Environnement et de la Lutte aux Changements Climatiques (MELCC), and Québec City will be reported and discussed. Comparison with the simulations from the Coordinated Regional Climate Downscaling Experiment (CORDEX-NA) ensemble in historical climate will then be presented in order to assess the global performance of climate models and possible bias. Future projections (RCP 4.5 and 8.5) for the 2040-2070 period will then be discussed. Consistency of climate change signals for the various indices will be assessed as well as uncertainties on projections through the comparisons of the various pairs of global and regional climate models.

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29/05/2020 13:15

ID: 10418 Contributed abstract

Increasing Winter Severity in Canada: An Assessment based on recent years.

E.Ray Garnett [1] , *Madhav Khandekar* [2]

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[2] Retired Scientist Environment Canada

Presented by / Présenté par: ***E.Ray Garnett***
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Winters have become colder, snowier and possibly longer in most regions of Canada, in recent years. The latest winter season (2019-20) has witnessed an extreme cold snap over most of the Prairies with low temperatures dipping down to -20°C to -30°C during the week of January 13-20 2020; that same week brought low temperatures at -40°C and lower in the interior regions of British Columbia. In Atlantic Canada, Newfoundland saw an epic blizzard in mid-January which dumped over 75 cm of snow over most of the Island which remained 'cut-off' from the rest of Canada for over two days. The winters of 2014/15 and 2016/17 were also colder and snowier in many regions of Canada and in particular over the city of Vancouver which recorded one of largest snowfalls in recorded history (over 60 cm in

December 2016). Since the new millennium, mean temperature (December -February) over the Prairies has cooled down by about 2°C (-11.3 °C to -13.5 °C).
In this talk, we present a brief analysis of recent cold winters in Canada, against the backdrop of the ongoing debate on "Global Warming and Climate Change." Our analysis provides a number of examples of cold extremes over various regions of Canada in recent years; it further provides a plausible mechanism of such cold extremes using large-scale atmospheric-ocean anomalies such as the Pacific North American (PNA) Index, Pacific Decadal Oscillation (PDO), North American snow cover anomalies and solar activity related to the approaching grand minimum foreseen in the next decade or so.
The talk will conclude with brief reference to the pervasive climate activism sweeping the 'Western World' at present.

Session: 2010071 Actual climatology and anticipated changes in winter precipitation (solid, mixed and liquid) and hail and their impacts - Part 2
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29/05/2020 13:30

ID: 10444 Contributed abstract

Changes in precipitation type distribution during the 1998 Ice Storm simulated under warmer conditions using the Pseudo-Global-Warming approach

Mélissa Cholette [1] , *Julie M. Thériault* [2]

[1] Centre ESCER, UQAM et Environment and Climate Change Canada
[2] Centre ESCER, UQAM

Presented by / Présenté par: ***Julie Theriault***
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Winter precipitation types observed at the surface when temperatures are near 0°C include snow, freezing rain, ice pellets, wet snow and rain. Damages to infrastructure can occur due to ice loading from freezing rain and wet snow accumulations. The intensity and the occurrence of winter storms are projected to change in the future due to warming of the Earth system. The goal of this research is to investigate the impacts of a warmer atmosphere on the simulation of winter precipitation types produced during a high-impact winter storm: the Quebec 1998 Ice Storm. To achieve this, simulations with the Weather Research and Forecasting (WRF) model coupled to a bulk microphysics scheme predicting the liquid fraction of mixed-phase particles are conducted under current and warmer conditions. This version of the Predicted Particle Properties scheme allows explicit parameterization of microphysical processes leading to ice pellets and wet snow. The Pseudo-Global-Warming (PGW) approach is used for the simulation of the storm under warmer conditions. This method consists of modifying the initial and lateral boundary reanalysis conditions used to simulate past weather events with climate perturbations from a GCM climate projection. Results include a general north-eastward migration of the rain-snow transition, with an increase in the amounts of wet snow, rain and freezing rain in PGW. Freezing rain still forms in southern Quebec despite these warmer conditions. Snow is generally changed to freezing rain whereas ice pellets and freezing rain are generally changed to rain. The extent of the melting layer aloft increases farther north in PGW and the presence of the Appalachians and

Laurentians contribute to a wider rain-snow transition area. Overall, this study addresses for the first time the changes in precipitation types using a mixed-phase microphysics scheme to better understand the impacts of warmer environmental conditions on winter precipitation type transitions.

Session: 2010071 Actual climatology and anticipated changes in winter precipitation (solid, mixed and liquid) and hail and their impacts - Part 2
Climatologie présente et changements anticipés des précipitations hivernales (solides, mixtes et liquides) et de la grêle et leurs impacts - Partie 2

29/05/2020
13:45

ID: 10483 Contributed abstract

Chasing cold season precipitation: The development and deployment of the Urban Mobile weather Station (MUST), Montreal, Canada

Hadleigh Thompson [1] , *Julie Thériault* [2] , *Mathieu Lachapelle* [3] , *Guillaume Dueymes* [4] , *Philippe Gachon* [5] , *John Gyakum* [6]

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Presented by / Présenté par: ***Hadleigh Thompson***
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Difficulties in differentiating precipitation types around 0°C complicates the accurate forecasting of potentially hazardous weather events such as winter-time freezing rain, ice pellets and wet snow. To combat uncertainties such as the vertical atmospheric profile, type and phase of precipitation aloft and the surface, and surface energy fluxes associated with storms around 0°C, we have developed the Mobile Urban weather Station (MUST). We present an overview of this transportable platform, which has the capacity for a vertically pointing micro rain radar, optical disdrometer, particle micro-photography, and a range of near-surface meteorological instrumentation. The primary application of the MUST is to conduct observations of storms and precipitation occurring at or near 0°C in the St Lawrence river valley. This region is particularly affected by freezing rain during winter, and the MUST allows for detailed manual surface observations to be conducted for the duration of such events. Preliminary analysis and results from a freezing rain event in early 2020 are presented, where the co-location of instrumentation and human observations has contributed to a better understanding of fine-scale processes and atmospheric conditions leading to this hazardous winter precipitation. In addition to its primary use, the instrumentation and transportable platform can easily be adapted for other seasons to monitor heavy rainfall during the spring that can lead to flooding or to heatwaves in urban areas. The MUST is also an integral part of a larger Earth Observing System project, being led by McGill University.

Session: 2010071 Actual climatology and anticipated changes in winter precipitation (solid, mixed and liquid) and hail and their impacts - Part 2
Climatologie présente et changements anticipés des précipitations hivernales (solides, mixtes et liquides) et de la grêle et leurs impacts - Partie 2

29/05/2020 14:00

ID: 10422 Contributed abstract

Changes in winter precipitation transition regions using an object-based method with convection-permitting climate simulations in a warmer climate

Sébastien Marinier [1] , *Julie Thériault* [2]

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Presented by / Présenté par: ***Sébastien Marinier***
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Winter storms associated with near surface temperature near 0°C can have severe consequences on power networks, transports and health. A precipitation transition is usually associated with freezing rain, wet snow and/or ice pellets or a combination of them. This transition region is bound by only rain and only snow. The exact type of precipitation can largely impact the severity of storms and could change in the context of global warming. In this work, convection permitting climate simulations from Liu et al. (2017) with a pseudo-global warming (PGW) method were used to study the impact of a warmer climate on the properties of the precipitation transition regions during winter storms over northeastern North America. The time-domain version of the method for object-based diagnostic evaluation (MTD) was used to identify those transition regions, follow their temporal evolution to identify severe storms and study the changes in their properties. The results show a decrease in the number of objects thereby identified and a general northward shift of those transition regions for the PGW simulation compared to the current climate (CTRL). This method allowed to identify severe events across the domain instead of locally and then study the changes within those objects with respect to their center. A parallel is made between the transition region location and the location of the low pressure system for both simulations, and changes for the temperature, vertical winds and mixing ratios aloft are looked at during the most severe storms identified with MTD. The fraction of liquid precipitation in the transition region will change in a warmer climate. Overall, this study contributes to better understand how the distribution of winter precipitation will change in the future.

Day 5 - 1 June 2020

Convener: Dr. David Sills

On September 21st, 2018, a late-season tornado outbreak struck the Ottawa area and surrounding regions in Ontario and Quebec. Seven supercell tornadoes caused up to EF3 damage resulting in over $300M in insured losses. Post-event surveys by ground teams with drones, and subsequent analysis using high-resolution satellite and aircraft aerial data, have resulted in what is likely the most well-documented tornado outbreak in Canadian history. This session welcomes multi-disciplinary contributions that will explore various aspects of the event.

Session: 2010040 Northern tornadoes - Part 1 Tornades du nord - Partie 1

01/06/2020 11:00

ID: 10253 Contributed abstract

Tornado Terror in the National Capital Region: An Overview of the Tornado Outbreak of September 21st, 2018 in Eastern Ontario and Southern Quebec from the Perspective of the Ontario Storm Prediction Centre

Arnold Ashton [1]

[1]

Presented by / Présenté par: ***Arnold Ashton***
Contact: arnoldashton@hotmail.com

On September 21st 2018, seven tornadoes swept through the National Capital and surrounding regions. The outbreak was extraordinary in its late season intensity and impacts on many urbanized areas. This introductory talk will place it in context to past significant Canadian tornado events. It will provide a meteorological overview of the storm environment, then put the listener inside the shoes of a meteorologist from the Ontario Storm Prediction Centre, walking through the evolution of the outbreak with a detailed look at real-time RADAR data.

Session: 2010040 Northern tornadoes - Part 1 Tornades du nord - Partie 1

01/06/2020 11:15

ID: 10240 Contributed abstract

Tornado Terror in the National Capital Region: A Warning Preparedness Meteorologist's Perspective

Peter Kimbell [1]

[1] Environment Canada

Presented by / Présenté par: ***Peter Kimbell***
Contact: peter.kimbell@canada.ca

The Meteorological Service of Canada employs a number of Warning Preparedness Meteorologists (WPMs) who are the liaison between the forecast offices and two key clients: the media, and emergency management organizations at all levels of government. The Ottawa WPM was on duty on September 21, 2018. This talk will provide his perspective – in particular, regarding communications with the media, the storm damage surveys, Environment Canada's new Alert Ready system, and tornado climatology.

Session: 2010040 Northern tornadoes - Part 1 Tornades du nord -

ID: 10277 Contributed abstract

NTP Post-Event Analysis for the 21 Sep 2018 Tornado Outbreak

Aaron Jaffe [1] , *David Sills* [2] , *Gregory Kopp* [3] , *Lesley Elliott* [4] , *Emilio Hong* [5]

[1] Western University
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Presented by / Présenté par: ***Aaron Jaffe***
Contact: ajaffe22@uwo.ca

On September 21, 2018, a significant tornado outbreak impacted a number of areas in and around the Ottawa-Gatineau region in eastern Ontario and southern Quebec. In total, seven tornadoes were identified in this outbreak: one EF1, five EF2s, and one EF3. Due to in-depth investigations by the Northern Tornadoes Project (NTP) and the Meteorological Service of Canada, this outbreak is one of the most well-documented in Canadian history. Two of the seven tornadoes from this event were discovered by NTP, and details and data were significantly improved by NTP for the other five.

Two NTP survey teams were dispatched following reports of severe damage in Ottawa and Gatineau and ground surveys were conducted from September 22 to 24. These surveys explored the damage from the Calabogie-White Lake, Kinburn-Dunrobin-Gatineau, and Ottawa (Nepean) tornadoes, as these were the events with the most structural damage, while the other four tornadoes tracked through remote or rural areas. From these ground surveys, wind speed estimates were made for the most severely impacted locations based on observed damage to various damage indicators such as houses, small apartment buildings, trees, and electrical utilities. From these observations, Dunrobin, Gatineau, and Ottawa (Nepean) were assessed as having estimated maximum wind speeds of 245 km/h, 235 km/h, and 210 km/h, respectively.

In the weeks following the outbreak, NTP performed satellite analyses for each of the seven tornadoes. These analyses provided preliminary path lengths, maximum path widths, and EF-Scale ratings for the tornadoes, which were especially important for the four events that were not covered by ground surveys. In November of 2018, high-resolution aerial imagery was collected for each of the events, and then analyzed by NTP in the winter of early 2019. These analyses allowed the determination of final path dimensions and EF-Scale ratings for each of the seven tornadoes.

Session: 2010040 Northern tornadoes - Part 1 Tornades du nord - Partie 1 01/06/2020 11:45

ID: 10437 Contributed abstract

Bracing for Future Outbreaks: Review of Canadian Design Codes for Tornado-Resilience of Houses

Sarah A. Stevenson [1], *Gregory A. Kopp* [2], *Ayman M. El Ansary* [3]

[1] University of Western Ontario
[2] University of Western Ontario
[3] University of Western Ontario

Presented by / Présenté par: ***Sarah Stevenson***
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As the country was reminded following the Ottawa-area tornado outbreak of September 21, 2018, high-wind events cause significant damage to structures and property. In particular, light-frame wood homes and small buildings can experience catastrophic damage that results in loss of the structure and all contents. As with many regions, Canadian homes are built to a prescriptive building code. These codes are based on historical construction methods and the structural design components have remained unchanged across several decades. This is despite a significant body of research that is available to inform updates. It is believed that current performance targets are not stringent enough, and that tornado risk could be additionally addressed by rectifying a few specific weak links.

A vast database of damage survey observations has informed ongoing research that assesses the failure modes for residential structures in tornadoes. Components that are commonly observed to fail are of primary interest, namely roof sheathing, roof-to-wall connections, and discontinuities in wall-to-floor links. Experimental and analytical work has verified many of the observed weak links and identified characteristics that may make certain houses more susceptible to damage during a tornado. The present work reviews the common failure modes observed in residential structures and presents recommendations for improving their resilience. Examples from the Ottawa-area outbreak will be discussed to highlight the weaknesses that caused such extreme loss to occur.

Ongoing work includes inspections of new houses under construction, collaboration with members of the homebuilding industry to assess the practicality of proposed strengthening solutions, and development of detailed models for residential structural systems to accurately estimate failure wind speeds for the range of houses allowed by the building code. An additional outcome of reliability modelling for residential structures and their components is the refinement of the EF-Scale assessment of degrees of damage for residential structures.

Session: 2010040 Northern tornadoes - Part 1 Tornades du nord - Partie 1
01/06/2020 12:00

ID: 10443 Contributed abstract

Wind structure in vicinity of tornadic thunderstorms deduced from cloud motion in satellite imagery using an optical flow technique

Robert Rabin [1]

[1] NOAA National Severe Storms Lab

Presented by / Présenté par: ***Robert Rabin***
Contact: Rabin@ssec.wisc.edu

This presentation will compare the wind structure above thunderstorms for three events: the Ottawa tornadoes on 21 September 2018, a long-track EF4 tornado near Lawrence Kansas on 28 May 2019, and a short-lived EF3 tornado which hit Caddo Mounds, TX on 14 April 2019. The high temporal resolution of geostationary satellite imagery was used to estimate winds from cloud motion at 1-minute intervals using an optical flow technique. Widespread divergence and high speed winds were observed to develop in vicinity of overshooting cloud tops during the lifetime of the tornadoes. These signatures are indicative of strong outflow from intense updrafts near the top of the storms. Such observations may be complimentary to radar observations in monitoring trends of storm severity. In most cases, the storms could be identified by relatively slow cloud movement of the coldest cloud tops.

Session: 2010040 Northern tornadoes - Part 1 Tornades du nord - Partie 1

01/06/2020 12:15

ID: 10377 Contributed abstract

Tornado Hazard and Exposure Model for Canadian Communities

Gabriel Narancio [1] , *Djordje Romanic* [2] , *Jubayer Chowdury* [3] , *Horia Hangan* [4]

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Presented by / Présenté par: ***Djordje Romanic***
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Recently, on September 21st, 2018, an outbreak of six tornadoes with the strongest one being a high-end EF -3, devastated the Ottawa -Gatineau area in Canada causing damages that might approach US$100 million. A set of experiments was performed in the WindEEE Dome tornado simulator at Western University to experimentally investigate the resilience of a Canadian community to tornado damages. A neighborhood in Dunrobin, Ontario that was ripped apart by an EF-3 tornado during the Ottawa-Gatineau tornado outbreak is chosen as a testbed for the study. The induced pressures on the façade of 8 houses were measured for different tornado categories and paths. The first goal is to experimentally replicate the conditions in the wind simulator that is as close as possible to the real event and provide an estimate of damages using the experimental data. The second goal is to perform a simple parametric study in the wind simulator and estimate the potential damage that would have been inflicted on the Dunrobin community by the same tornado (i.e., EF3) that traversed the community following a different path. Lastly, the potential influence of the different strengths of tornadoes on the Dunrobin community given the same footprint trajectory as the observed one will also be investigated. These experimentally determined damages will afterwards be compared against the losses reported by the insurance industries. This paper only focuses on the experimental technique behind this comprehensive study.

Much of the world's research on tornadoes has been done in the United States, and even then has been focused mainly in the southern parts of that country. However, recent studies in Europe and Canada documenting and characterizing 'northern' tornadoes have raised awareness in both communities about the tornado risk that has gone under-appreciated for many years. This session welcomes contributions on northern tornadoes and the research undertaken to study them, including new techniques and sources of data. It will include an invited presentation by a representative from the European Severe Storms Laboratory, the institution where most European research on tornadoes has been undertaken.

Session: 2010041 Northern tornadoes - Part 2 Tornades du nord - Partie 2

01/06/2020 13:00

ID: 10322 Invited session speaker

Tornadoes in Europe: What we have learned so far

Bogdan Antonescu [1] , *Pieter Groenemeijer* [2] , *Thilo Kühne* [3] , *David M. Schultz* [4] , *Tomáš Púcik* [5] , *Alois Holzer* [6]

[1] European Severe Storms Laboratory, and National Institute of Research and Development for Optoelectronics INOE2000

[2] European Severe Storms Laboratory

[3] European Severe Storms Laboratory

[4] Centre for Atmospheric Science, School of Earth and Environmental Sciences, and Centre for Crisis Studies and Mitigation, University of Manchester

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Presented by / Présenté par: ***Bogdan Antonescu***
Contact: bogdan.antonescu@essl.org

The European Severe Storms Laboratory (ESSL), founded in 2006 by scientists across Europe, aims to advance the science and forecasting of severe storms in Europe. One of the key activities of the ESSL is the development and management of the European Severe Weather Database (ESWD), a unique pan-European database. In this presentation, we explore the ESWD and show that, despite what is often assumed by the general public and even by some meteorologists and researchers, tornadoes do occur in Europe and are associated with injuries, fatalities, and damages. At the same time, this presentation will highlight the central role of ESSL among the scientific and forecasting communities in advancing the knowledge and increasing awareness of European tornadoes. First, we will present a short history of tornadoes in Europe and of the development of ESSL. Second, using reports from the ESWD between 1800–2019 (i.e., 14,500 reports) we will present a climatology of European tornadoes and compare it with climatologies constructed for the United States and Canada, focusing mainly on the period 1950–2019. We will also show a comparison between the environments leading to tornadoes in Europe and those associated with tornadoes in the United States. Third, we will summarize the current understanding of the tornado threat to Europe by showing the changes in tornado injuries and fatalities since the 1950s and by estimating the damages associated with European tornadoes. Fourth, will discuss the use of EF-scale for rating European tornadoes and also the research that ESSL is currently conducting together with international partners on the implementation of an International Fujita Scale.

Session: 2010041 Northern tornadoes - Part 2 Tornades du nord - Partie 2

01/06/2020 13:30

ID: 10276 Contributed abstract

The Northern Tornadoes Project - Uncovering Canada's True Tornado Climatology

David Sills [1], *Gregory Kopp* [2], *Lesley Elliott* [3], *Aaron Jaffe* [4], *Elizabeth Sutherland* [5], *Connell Miller* [6], *Joanne Kunkel* [7], *Emilio Hong* [8], *Sarah Stevenson* [9]

[1] Western University
[2] Western University
[3] Western University
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Presented by / Présenté par: ***David Sills***
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With most of Canada's population located along its southern border, large areas of the country are sparsely populated. Severe weather reports are rare when thunderstorms occur there. For this reason, it has been difficult to accurately assess Canada's true tornado climatology and risk. Establishing a reliable baseline for tornado-related climate change studies is also important.

The Northern Tornadoes Project, led by Western University, is an ambitious multidisciplinary initiative aimed at detecting and documenting every tornado that occurs across Canada. A team of meteorologists and wind engineers collects research-quality data during each damage investigation, via thorough ground surveys and high -resolution satellite, aircraft and drone imaging. Crowdsourcing through social media is also key to tracking down events, particularly in areas where there is little to damage such as large swaths of the Prairies. An open data website allows sharing of NTP data sets and analyses. In addition, research is conducted to improve our ability to detect and accurately assess tornadoes that affect forests, cropland and grassland.

Pilot investigations were carried out during the warm seasons of 2017 and 2018, with the scope expanding from the detection of any tornadoes in heavily forested regions of central Canada in 2017 to the detection of all EF1+ tornadoes in Ontario plus all significant events outside of Ontario in 2018. The 2019 season was the first full national campaign aimed at systemically collecting research-quality tornado data across the entire country. To date, NTP has found over 70 tornadoes that otherwise would not have been identified, more than the current national annual average frequency of 61.3 tornadoes.

Session: 2010041 Northern tornadoes - Part 2 Tornades du nord - Partie 2

01/06/2020 13:45

ID: 10263 Contributed abstract

Remote Sensing of Tornado Damage

Connell Miller [1] , *David Sills* [2] , *Gregory Kopp* [3]

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Presented by / Présenté par: ***Connell Miller***
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The objectives of the Northern Tornadoes Project (NTP) are to study tornado occurrence and assess true tornado risk in Canada. This is accomplished by obtaining high-resolution, research-quality data for as many tornado events in Canada as possible. Although tornadoes in urban areas are often well documented, there are large regions in Canada where tornadoes are expected to occur but may go undetected due to the low population density, or lack of access in heavily forested areas. To help bridge the gap in tornado observation data in these remote non-urban areas, NTP relies heavily on aerial imagery to obtain research-quality data. However, aerial photography from traditional aircraft can take months to obtain, which leads to delays in determining tornado rating, and may not capture the full scope of damage due to the area being cleaned up over those months. In 2019, this led NTP to begin developing its own in-house remote sensing program by using remotely piloted aircraft systems (commonly known as drones).

By flying drones over damaged areas using pre-programmed grids, orthomosaic maps can be generated. Orthomosaic maps are made up of a series of individual photos which have been merged to form one composite image that has been adjusted for topographic relief, lens distortion, and camera tilt. These corrected composite images allow for the same accuracy as satellite or aerial imagery, but with higher resolution and a faster deployment time. This presentation will present orthomosaic mapping from the 2019 Canadian tornado season, and how these drone-obtained images can be processed to generate other products such as dynamic mosaics, digital surface models, digital terrain models, and 3D models. Finally, the lessons learned, as well as the plan for the 2020 tornado season to attempt beyond visual line of sight (BVLOS) flights will be discussed.

Session: 2010041 Northern tornadoes - Part 2 Tornades du nord - Partie 2

01/06/2020 14:00

ID: 10518 Contributed abstract

Tornado Damage Estimation by Combining Wavelet and CNN Based Technology from UAV (Drone) Database

Radhika Sudha [1] , *Prabhmeet Singh* [2] , *Archana Swaminathan* [3] , *Yukio Tamura* [4]

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Presented by / Présenté par: ***Radhika Sudha***
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Canada experiences the second-highest number of tornadoes in the world, with around 80 reported/unreported every year. Most occur in southern Ontario, the southern Canadian Prairies and southern Quebec. More than 95% are less than EF3 in damage intensity level and cause minor damage to roofs, chimneys, tree branches and fences. Common building failures caused by strong tornado winds are overturning, racking (lateral collapse), translation or sliding (lateral movement) and material failure, with the latter being the most common. Building roofs are the most prone to damages, followed by walls and finally foundations. With increasing advancements in technology, it is possible to obtain high-quality close-range data using Unmanned Aerial Vehicles (UAV). In this paper, we analyze 2018-2019 tornado outbreaks in Canada and aim to identify the type and degree of structural damage, from UAV and compared the same with aerial and satellite imagery. These outbreaks were characterized by many confirmed tornadoes that even affected the national capital region over two days, with the strongest moving 80km from Dunrobin, Ontario to Gatineau, Quebec, which measured EF3 on the intensity scale with winds reaching speeds up to 74m/s (165mph). We propose to use two different methods to perform structural damage assessment: Wavelet based feature extraction and custom deep Convolutional Neural Network (CNN) for feature extraction and classification. We then compare the results keeping accuracy and computational time constant. Next we compare the results with those obtained from other conventional image processing and feature extraction methods. The results are validated by comparing their correlation with on-field investigation data. Thus, by analyzing the degree of structural damage in real-time, we can prioritize regions for immediate evacuation and provide medical aid.

Session: 2010041 Northern tornadoes - Part 2 Tornades du nord - Partie 2
01/06/2020 14:15

ID: 10434 Contributed abstract

USING DEEP NEURAL NETWORKS TO AUTOMATE TREE-FALL PATTERN DETECTION

William Wang [1] , *Gregory Kopp* [2] , *David Sills* [3] , *Daniel Rhee* [4] , *Mark Daley* [5] , *Emilio Hong* [6]

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[3] University of Western Ontario
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6 University of Western Ontario

Presented by / Présenté par: ***William Wang***
Contact: william.ottawa@yahoo.com

On average, approximately 60 tornadoes are detected in Canada each year; however, it is believed that many often go undocumented due to the low population density in the northern regions of Canada. One of the goals of the Northern Tornadoes Project is to identify and collect data on these undetected events to more effectively assess and identify associated risks. Since over 40% of Canada is covered by forests, sometimes, the only retainable damage indicator that suggests there has been tornado activity is trees. Often, it can be very time-consuming to manually distinguish tornadic activity in forested areas and even harder to determine the tree-fall patterns. Calculating tree-fall patterns can help distinguish between tornado versus downburst damage and determine the rating on the Enhanced Fujita Scale.

In recent years, improved algorithmic efficiency has led to the development of faster and smaller neural networks, especially in the field of computer vision (CV). CV tasks like image classification, object detection, and instance segmentation have all seen vast improvements in computational efficiency and speed. Mask R-CNN is state of the art deep neural network aimed to solve instance segmentation problem in machine learning. It identifies each object instance of each pixel for every known object returning the object bounding boxes, classes and masks from an input image. Given an image of treefall, Mask R-CNN can detect the number of fallen trees, their locations and their tree-fall angle.

This presentation will cover Mask R-CNN and its implementation to automatically identify tree-fall patterns after extreme wind events. This presentation will compare Mask R-CNN with various other methods and discuss the testing results of these implementations. Finally future steps of integrating deep learning using neural networks to improve the analysis of tornadoes and other extreme wind events will be discussed.

Convenor: Jinyu Sheng, Guoqi Han, Ram Yerubandi

This special session will focus on all aspects of monitoring and modelling of physical and biogeochemical processes in coastal domains, shelf seas, estuaries and inland waters. Topics include but are not limited to coastal physical oceanography, storm surges, tsunamis, estuarine dynamics, hydrology and hydrodynamics of large lakes, mixing and dispersion of materials. We also invite contributions related to both observational and modelling aspects of biogeochemistry in coastal and inland waters.

We expect that papers submitted to this session will be of two main types. The first type will focus on improving our limited knowledge of physical and biogeochemical conditions over coastal and inland waters in the past and present climate. The second type will focus on predictions and examinations of changes in marine conditions over coastal and inland waters, including the Canadian Arctic waters, due to the climate change.

Session: 2010360 Coastal Oceanography and Inland Waters - Part 1
L'océanographie côtière et les eaux intérieures - Partie 1 01/06/2020 13:00

ID: 10288 Contributed abstract

The grounding of floating objects

Rich Pawlowicz

[1] University of British Columbia

Presented by / Présenté par: ***Rich Pawlowicz***
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The recent commercial development of satellite-monitored "theft trackers" has allowed oceanographers to develop extremely cheap and hence expendable surface drifters, suitable for coastal areas, for which positions can be determined every 10 minutes for several weeks. Currently we have deployed more than 400 of these in the Salish Sea, British Columbia (Pawlowicz, et al.,, Estuarine Coastal and Shelf Science, 2019). Although the primary goal of these deployments was to study mean flow and dispersion in this estuarine system, a surprising and unforeseen aspect of this dataset is that it provides an unprecedented view of the the manner in which floating objects ground on coastlines. Not only can determining whether or not a drifter is grounded be a sometimes ambiguous process, but a statistical analysis of the grounding dataset shows that the probability of grounding can be parameterized in a scale-independent fashion, which should allow for better predictions of grounding in numerical simulations of particle tracks.

Session: 2010360 Coastal Oceanography and Inland Waters - Part 1
L'océanographie côtière et les eaux intérieures - Partie 1 01/06/2020 13:15

ID: 10581 Contributed abstract

The role of wave-current interactions on the upper ocean circulation and vertical mixing under hurricane conditions

Colin Hughes [1] , *Guoqiang Liu* [2] , *William Perrie* [3] , *Jinyu Sheng* [4]

[1] Dalhousie University, Bedford Institute of Oceanography
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Presented by / Présenté par: ***Colin Hughes***
Contact: Colin.Hughes@Dal.ca

Ocean surface gravity waves contribute to the upper ocean circulation and vertical mixing through air-sea interactions, wave breaking, Coriolis-Stokes forcing, Lagrangian Mean (LM) currents, Langmuir turbulence (LT) and the vortex force. This study examines the impact of surface waves on the turbulent kinetic energy (TKE), thermal structure and currents in the upper ocean. Three experiments were conducted using idealized hurricanes moving at two different constant translation speeds. One experiment includes both LT and LM but not other wave effects (LT+LM) and another experiment includes the LM only (LMOnly). An experiment without wave effects also was conducted (CircOnly). Model results demonstrate that LT cools the sea surface temperature (SST) and the upper mixed layer, while warming the water column just below the mixed layer. The upper ocean

currents are also reduced in the LT+LM experiment relative to LMOnly and CircOnly. Furthermore, LT greatly enhances the TKE (up to ~30%) in comparison with LMOnly and CircOnly. Wave heights are larger during the case involving a faster moving hurricane due to the "trapped fetch" effect. However, LT-related impacts on the temperature, currents and TKE extend to much greater depths during the slower moving hurricane case. Future studies will consider other wave effects listed above, additional LT parameterizations and the effects of currents on waves.

Session: 2010360 Coastal Oceanography and Inland Waters - Part 1
L'océanographie côtière et les eaux intérieures - Partie 1 01/06/2020 13:30

ID: 10258 Contributed abstract

Idealized Numerical Modeling of Internal Wave Propagation Through Density Staircases

Mikhail Schee [1] , *Nicolas Grisouard* [2]

[1] University of Toronto
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Presented by / Présenté par: ***Mikhail Schee***
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The Arctic Ocean contains a warm layer originating from the Atlantic Ocean below the pycnocline which has a thermohaline staircase structure that inhibits vertical mixing. If this heat were to rise to the surface, the rate of sea ice loss would increase dramatically. Wind stress and ice floes generate internal waves which can cause vertical mixing. As the ice cover in the Arctic continues to decline, it will be important to predict how these changing internal waves propagate through such stratification profiles. Here, we investigate how density staircases enhance or limit downward near-inertial wave propagation. We use direct numerical simulations to solve the Boussinesq equations of motion using spectral methods. We simulate the propagation of internal waves through a vertically stratified fluid which includes one or more steps (i.e., mixed layers). We find that we reproduce the results of laboratory experiments showing transmission and reflection of internal waves from one or two mixed layers. Further, we develop diagnostic tools to compute vertical energy fluxes of internal waves. We then extend our parameter regime to simulate the propagation of internal waves through a more realistic stratification profile tending toward that of the Arctic pycnocline.

Session: 2010360 Coastal Oceanography and Inland Waters - Part 1 L'océanographie côtière et les eaux intérieures - Partie 1 01/06/2020 13:45

ID: 10398 Contributed abstract

Modelling internal tides in the Strait of Canso

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Presented by / Présenté par: ***Adam Drozdowski***
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Internal tide dynamics in the Strait of Canso are investigated by means of a 3-d circulation model. The embayment, an active shipping port located in eastern Nova Scotia, was found to have M2 baroclinic velocities occasionally reaching 0.15 ms -1 and typically faster than the barotropic tide. A complex internal tide structure develops inside the strait, characterized by the first vertical mode, and highly sensitive to the details of stratification. A region near the mouth of the strait, with a strong cross-bathymetry barotropic flow was identified as the main generating site. The regular 'canyon-like' features of the strait concentrate the energy towards the bottom and head, and under favorable conditions reflect energy from the head, forming a standing wave. The modelling study found that although some internal tide is generated year-round, only summer stratification conditions were favorable for standing wave development, due to both increased internal energy levels and longer wavelengths capable of transporting the energy further up the strait. A balanced internal energy budget for the area highlights a tendency towards local dissipation, and enhanced mixing rates. Persistent convection cells and upwelling zones suggest possible impacts on biological activity, sediment and oil spill dynamics in the region. The findings are validated with current meter and water level observations.

Session: 2010360 Coastal Oceanography and Inland Waters - Part 1 L'océanographie côtière et les eaux intérieures - Partie 1

01/06/2020 14:00

ID: 10458 Contributed abstract

Spatial and temporal origins of the La Perouse low oxygen pool: A combined Lagrangian statistical approach

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Presented by / Présenté par: ***Susan Allen***
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The lowest oxygen on the shelf of the West Coast of Canada occurs on La Perouse Bank beneath the Juan de Fuca Eddy. This water was surveyed in August 2013 and found to be

unconnected to the ongoing upwelling, including that through the canyons, and well-mixed. Both properties suggested the water was months rather than weeks old. Previous work has shown the importance of both in situ remineralization and the source waters to the lowness of the oxygen. Here we evaluate a 3-D numerical simulation (NEP36) with the observations. Using backward Lagrangian tracking we find the source, in time and space, and the pathways of the pool waters. With statistical techniques we show the origin of the water properties and estimate the remineralization rate. Surprisingly, results show the strong southern origin of the waters, including waters lighter than the California Undercurrent water. The role of submarine canyons in the pathways is clearly illustrated even in this relatively coarse numerical model.

Session: 2010360 Coastal Oceanography and Inland Waters - Part 1 L'océanographie côtière et les eaux intérieures - Partie 1

01/06/2020 14:15

ID: 10292 Contributed abstract

A coupled circulation-sea ice model of the eastern Canadian seaboard

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Presented by / Présenté par: ***Kyoko Ohashi***
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Circulation, sea ice, and hydrography over the eastern Canadian seaboard have large temporal and spatial variabilities. A coupled circulation-sea ice modelling system based on ROMS (Regional Ocean Modeling System) and CICE (the Los Alamos sea ice model) is used to study these variabilities and the ways in which the circulation and hydrography of the region's interconnected areas affect each other. This modelling system was developed as part of an ongoing effort to update an operational circulation forecast system for this region and is the outermost ("Level 1") member of a system of three nested-grid models with progressively finer grids. The innermost model (covering the central Scotian Shelf) provides inputs for simulations of oxygen utilization over the shelf. The use of nested grids allows simulations by the innermost model to include the effects of large-scale phenomena while resolving circulation features on the O(1 km) scale. The performance of the Level 1 modelling system is evaluated using tide gauge measurements, in situ measurements from the Atlantic Zone Monitoring Program, and remote sensing observations. In this study we focus on connections among the areas within the model domain, such as the manner in which circulation over the Scotian Shelf is affected by flows from upstream (i.e., from the Gulf of St. Lawrence and the Newfoundland Shelf) as well as by intrusions from deeper waters.

ID: 10251 Contributed abstract

Position of the surface salinity front in the St. Lawrence Estuary

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The surface salinity front, defined as salinity 1, is reported using various type of instruments and over many years. The top 5 meters of the water column is the layer used to link the various type of observations. The geographical domain covers the estuary between Quebec City and Île aux Coudres, a 75 km span. The St. Lawrence River daily flow is known at Quebec City from a recent hindcast that covers the period of observations (2000 to 2018). Water level observation in the domain is provided by tidal gauges from the Canadian Hydrographic Service. Observation of salinity and temperature is reported from three ship surveys, from tidal gauges and from a thermosalinograph equipment on-board a ship of opportunity transiting semiweekly through the area. The position of the salinity front varies with the water level over 17 km and with the river flow over 24 km. As expected, the position of the front along the South shore is further downstream than its position on the North shore. The difference is 20 km on average and increases with the River flow.

ID: 10429 Contributed abstract

Coupling of Estuarine Circulations in a Network of Fjords

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Presented by / Présenté par: ***Shiliang Shan***
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The Kitimat Fjord System in the northern British Columbia coast consists of multiple

interconnected fjords. Based on recent observations and numerical model results, we find that the fjords/channels around the Hawkesbury Island, including the Douglas Channel, Devastation Channel, Gardner Canal, and Verney Passage, are tightly coupled and the hydrodynamic head of the Kitimat Fjord System is the Kitlope River at the head of Gardner Canal. The fresh water leaving Gardner Canal bifurcates at a triple junction: (1) north through Devastation Channel to Douglas Channel and (2) west along Verney Passage to Wright Sound. The partitioning of the fresh water leaving Gardner Canal has substantial implications for interpreting estuarine circulation and water exchange of the system. The remotely sensed freshwater plume, surface drifter trajectories, and temperature profiles suggest that the fresh water from Gardner Canal contributes to the estuarine circulation in the Douglas Channel. Two model-based estimates suggest that about 60% of the fresh water from Gardner Canal takes the Devastation Channel pathway. The wind causes the Devastation Channel freshwater fraction to range from 45% to 70%. These findings have practical implications on operational modelling of upper ocean currents in the main shipping artery, Douglas Channel, and the transport of potential pollutants (e.g., oil spill) in the region.

Session: 2010361 Coastal Oceanography and Inland Waters - Part 2 L'océanographie côtière et les eaux intérieures - Partie 2

01/06/2020 15:30

ID: 10516 Contributed abstract

Topographic influences on wind driven upwelling in the Strait of Georgia

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Presented by / Présenté par: ***Ben Moore-Maley***
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Wind driven upwelling is common in lakes and coastal seas, and can produce rapid changes in surface temperature, nutrients, pH and dissolved oxygen. The strength of upwelling in these basins is controlled primarily by wind stress, stratification and basin scale; the competing effects of these quantities are summarized by the Wedderburn number, defined as the bulk Richardson number multiplied by the aspect ratio of isopycnal tilting. In the Strait of Georgia, rapid changes in surface properties following wind events are frequently observed; for example late season phytoplankton blooms are supplied by wind driven nutrient pulses from below the pycnocline. While mixing is generally thought to be the dominant driver of these pulses, the Wedderburn numbers associated with these events support upwelling as a significant alternative mechanism. In a 10-year hindcast of the 3-D, high resolution Salish Sea NEMO model configuration, SalishSeaCast, the prevailing alongshore wind climatology drives frequent, cross-channel surfacing of the pycnocline. Principal component analysis of the hindcast surface nitrate record reveals this wind driven, cross-channel upwelling response to dominate the first two modes of spatial variability

between late spring and early fall. Significant variability in upwelling depth and offshore pycnocline front displacement between individual upwelling events in the hindcast record are explained to first order by the Wedderburn number. However, this relationship begins to break down as the offshore bottom slope becomes more gradual. Previous studies have attributed this topographic dependence to advection-driven changes in the onshore velocity profile at low slope Burger number. Using a theoretical upwelling model that explicitly considers cross-shore advection, we similarly characterize the topographic dependence we observe in the hindcast in terms of slope Burger number. As a synthesis, we contrast regions of gradual versus steep bottom slope in the Strait and their implications for the environment.

Session: 2010361 Coastal Oceanography and Inland Waters - Part 2 L'océanographie côtière et les eaux intérieures - Partie 2

01/06/2020 15:45

ID: 10294 Contributed abstract

Development of a FVCOM model for Queen Charlotte Strait, BC

Yuehua (Andy) Lin [1], *Laura Bianucci* [2], *Maxim Krassovski* [3], *Michael G. G. Foreman* [4], *David B. Fissel* [5], *Todd Mudge* [6]

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Presented by / Présenté par: ***Yuehua (Andy) Lin***
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High-resolution hydrodynamic models of the coastal ocean can be used to assist the aquaculture industry and its regulators in different ways; for instance, they can provide information to select optimal locations for farms and to assess their particle/pathogen dispersal to the environment as well as farm-to-farm interactions. As part of a Program for Aquaculture Regulatory Research (PARR) project, we are developing a high-resolution model for Queen Charlotte Strait, BC. The model is an application of the unstructured grid, Finite-Volume, primitive equation Community Ocean Model (FVCOM). Currently, the horizontal resolution of the model grid ranges from 50 m at the Port Hardy region to 2000 m at the open ocean (Queen Charlotte Sound and northwest shelf of Vancouver Island). At the open ocean boundary, the model is one-way nested within the operational largescale Coastal Ice Ocean Prediction System for the West coast (CIOPS-W). The latter is developed by the Canadian Operational

resolution (~2.0 to 2.5km). At the surface, the FVCOM model is forced by the operational High-Resolution Deterministic Prediction System (HRDPS) from Environment and Climate Change Canada (ECCC), which provides surface winds and heat flux with a 2.5 km spatial resolution.

Benefitting from the operational ocean prediction system (CIOPS), and using the atmospheric predictions (HRDPS), this coastal ocean model would have the capacity to be operational and provide high-resolution coastal ocean nowcasts and forecasts up to 48 hours over the Queen Charlotte Strait area. In this presentation, we will describe the model in detail and provide preliminary results from the ongoing detailed evaluation of the model performance.

Session: 2010361 Coastal Oceanography and Inland Waters - Part 2
L'océanographie côtière et les eaux intérieures - Partie 2 01/06/2020 16:00

ID: 10580 Contributed abstract

Physical Oceanography of Northumberland Strait.

Nicolas Lambert [1] , *Joel Chassé* [2]

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Presented by / Présenté par: ***Nicolas Lambert***
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Knowledge about the past physical ocean states as well as their future climate projection is important to better understand environmental issues like hypoxia and acidification. It is also important for management activities like fish stock assessments and marine protected area delineation. A combination of historical observations and numerical models is used to investigate the physical oceanography of Northumberland Strait in the southern Gulf of St. Lawrence (sGSL). The circulation in Northumberland Strait is rather complex due to the interaction of tides, winds and remote forcing (e.g., storm surge). In terms of tides, the west side of the strait has more of a diurnal tidal cycle, while the east side exhibits a mixed character with both the diurnal and semi-diurnal components showing similarly amplitude. The tidal currents are larger in constrictions like off West Point, Wood Islands and around Pictou Island where they can reach up to 1.5 m/s. There is a large seasonal cycle of temperature in Northumberland Strait. Temperature could be around -1.5°C in winter and reach as high as 24-25°C at the surface in summer. Northumberland Strait is one of the warmest areas of the GSL in summer, with the bottom water reaching its highest temperatures in September. There is no stratification in shallow areas where the mixing is strong, but a thermocline can be seen in places where the depth is greater than 20 m. Salinity is typically lower on the western side of the strait due to the influence of the Miramichi River. When averaged over a relatively long period of time (e.g. monthly), the residual circulation is generally from west to east with a gyre on each side of the strait. At higher frequencies (days to a few weeks), the residual circulation can also at time be westward (from east to west).

Session: 2010361 Coastal Oceanography and Inland Waters - Part 2
L'océanographie côtière et les eaux intérieures - Partie 2 01/06/2020 16:15

ID: 10583 Contributed abstract

A model study of the sea ice variability in the Gulf of St. Lawrence

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Presented by / Présenté par: ***Yuan Wang***
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This study examines the temporal and spatial variability of sea ice formation and distribution in the Gulf of St. Lawrence (GSL) during 1998-2010 using a coupled circulation-sea ice model. This coupled model is based on the Nucleus for European Modelling of the Ocean (NEMO) and LIM2. The model domain covers the northwest Atlantic Ocean, from the Labrador Shelf to the Cape Hatteras and from the eastern Canadian coast to the Mid-Atlantic Ridge. The model horizontal resolution is 1/12o, with 50 vertical z-levels. The model forcing at the sea surface includes 6-hourly fields of short wave and long wave radiation, surface wind, air temperature, relative humidity, and precipitation taken from the Climate Forecast System Reanalysis (CFSR). The monthly climatology of freshwater runoff from fifteen major rivers is used in the model. The tidal forcing in the model consists of (a) tidal surface elevation and depth-mean currents of five major constituents at open boundaries and (b) tide-generating potential specified at each model grid. The model results present a reasonably well agreement with observed sea ice concentration and derived thickness from the Canadian Ice Service weekly regional charts, except for underestimations of sea ice thickness over the Magdalen Shallows. For the analysis of simulated sea ice, the GSL is divided into four dynamically distinct sub-regions. The characteristics of the interannual variability of sea ice and upper-ocean dynamics over the four sub-regions are discussed along with the sea ice budget and the role of oceanic heat fluxes.

Day 6 - 2 June 2020

Session: 2010362 Coastal Oceanography and Inland Waters - Part 3
L'océanographie côtière et les eaux intérieures - Partie 3 02/06/2020 13:00

ID: 10358 Contributed abstract

A Laptop Tide-Surge Model for the Northwest Atlantic

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Presented by / Présenté par: ***David Greenberg***
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We use T-UGOm, (Toulouse Unstructured Grid Ocean model) in non-linear, 2D time stepping mode to look at the combined surge and tide driving sea level of the Northwest Atlantic Coast. Calendar year

2015 is examined. The tides are driven by the specified open boundary constituents, gravitational forcing, loading and self attraction. The specified open boundary tide Wind stress and sea-surface pressure are obtained from the archived ECMWF ERA5 (reanalysis) hourly dataset. We calibrate using constituents at crossover points from satellite altimetry and compare model results to coastal tidal records and constituents from tide gauges. The agreement with tidal constituents from observations is excellent. Even without including ice and baroclinic effects, the predicted tidal residual is able to substantially reproduce non tidal components of the sea level record.

Session: 2010362 Coastal Oceanography and Inland Waters - Part 3
L'océanographie côtière et les eaux intérieures - Partie 3 02/06/2020 13:15

ID: 10291 Contributed abstract

Circulation and its Variability over the Northwestern Atlantic Ocean, A Numerical study using a Coupled Circulation-Ice Model

Jinyu Sheng [1] , *Yuan Wang* [2] , *Jorge Urrego-Blanco* [3] , *Youyu Lu* [4] , *Richard Greatbatch* [5]

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Presented by / Présenté par: ***Jinyu Sheng***
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Circulation over the northwest Atlantic Ocean (NWA) has significantly large spatial and temporal variability. A coupled circulation-sea ice model is applied to the NWA for examining the main physical processes affecting the general circulation, hydrography and their spatiotemporal variability over the region. The coupled circulation-ice model is based on the Nucleus for European Modelling of the Ocean (NEMO), with the Océan PArallélisé System as the ocean circulation component and Louvain-la-Neuve Ice Model as the sea-ice component. The model performance is assessed using various satellite remote sensing data and in-situ oceanographic observations. The coupled model reproduces general features of the observed tidal and subtidal circulations over the coastal and shelf waters of the NWA. Analyses of model results demonstrate that the interannual variability on the Labrador Shelf is mainly affected by the advection of variability from high latitudes by the Labrador Current. Over the Newfoundland Shelf and the Grand Banks, the interannual variability is significantly affected by the non-linear interaction between the Labrador Current and the Gulf Stream. Over the Scotian Shelf and the Gulf of St. Lawrence, the interannual variability is significantly affected by advection of anomalies produced over the Tail of the Grand Banks. The model results also demonstrate strong interactions between tides and vertical stratifications near tidal fronts, leading to substantial exchange between surface and subsurface waters in regions of the northwestern Gulf of St. Lawrence, the inner Gulf of Maine and Bay of Fundy. The tidal impacts in the seasonal mean circulation are significant over the St. Lawrence River Estuary, northwestern Gulf of St. Lawrence, southwestern Scotian Shelf, Gulf of Maine, and Bay of Fundy, and northern flank of the Georges Bank. moderate over the Scotian Shelf, and relatively weak over the Labrador and Newfoundland

Shelves,

Session: 2010362 Coastal Oceanography and Inland Waters - Part 3
L'océanographie côtière et les eaux intérieures - Partie 3 02/06/2020 13:30

ID: 10576 Contributed abstract

New operational Coastal Ice-Ocean Prediction Systems in support of the Oceans Protection Plan

Jean-Philippe Paquin [1] , *Gregory C. Smith* [2] , *Youyu Lu* [3] , *François Roy* [4] , *Stephanne Taylor* [5] , *Hauke Blanken* [6] , *Frédéric Dupont* [7] , *Ji Lei* [8] , *Sarah MacDermid* [9] , *Nancy Soontiens* [10] , *Jennifer Holden* [11] , *Audrey-Anne Gauthier* [12]

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Presented by / Présenté par: ***Jean-Philippe Paquin***
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In order to provide Canada with short-term ice-ocean predictions and oil spill fate and behavior forecasts for the Oceans Protection Plan, the Government of Canada CONCEPTS initiative (Canadian Operational Network of Coupled Environmental Prediction Systems) is developing two new coastal ice-ocean prediction systems. This presentation introduces the CIOPS for the West and East Coasts of Canada. The systems uses a 1/36° resolution (2km) configuration of the NEMO model. The CIOPS systems have been setup using a spectral nudging approach to down-scale the ocean analysis from the updated Regional Ice Ocean Prediction System (RIOPSv2), which now includes a full multivariate data assimilation system and an extension over the North Pacific Ocean.
The main aim is to present a brief overview of the CIOPS evaluation with a focus on the evaluation of the processes that influence the surface drift and the fate and behaviour of oil spills. The development of the two CIOPS is critical to another OPP initiative as their solution will be used to provide forcing to very high resolution port -scale models, designed to support emergency response and electronic navigation for six major high-risk ports in Canada.

ID: 10309 Contributed abstract

Using State-Space Models to Estimate the Carbon Inventory in the North-West Atlantic Ocean

Claire Boteler [1] , *Michael Dowd* [2] , *Eric C. J. Oliver* [3] , *Elias T. Krainski* [4] , *Douglas W. R. Wallace* [5]

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Presented by / Présenté par: ***Claire Boteler***
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The NW Atlantic Ocean is an important global sink for atmospheric carbon produced by anthropogenic activities. However irregular sampling of ocean carbon in both space and time make it difficult to capture a full picture of its spatio-temporal variations. We use data-centric, state space methods to improved estimates of Total Inorganic Carbon (TIC) using the GLOPAPv2 database (Olsen et al, 2016; Olsen et al, 2019). By predicting monthly TIC estimates sequentially through time using the ensemble Kalman filter, filling any data gaps, the result is a complete estimate with confidence intervals of the TIC time series for our region of interest. In this work, we compare different one step ahead prediction functions that utilize the relationship TIC has with other ocean variables (e.g. temperature, salinity, nutrients). This work is part of the larger goal of providing an improved estimate of the ocean's carbon inventory and the flux that is well-constrained by real observations.

ID: 10431 Contributed abstract

Regional Class 4 verification of the Canadian operational ice-ocean prediction systems

Yvonnick Le Clainche [1] , *Gregory Smith* [2] , *Jinshan Xu* [3] , *Fraser Davidson* [4] , *Yimin Liu* [5] , *Frédéric Dupont* [6]

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Presented by / Présenté par: ***Yvonnick Le Clainche***
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Ice-ocean analysis and forecasting systems have been developed and operationally implemented under the Canadian Operational Network of Coupled Environmental Prediction Systems (CONCEPTS), an inter-departmental initiative involving Environment and Climate Change Canada (ECCC), Fisheries and Oceans Canada (DFO) and the Department of National Defense (DND). A DFO Service Desk for Operational Oceanography (SeDOO) was recently established at the ECCC Canadian Centre for Meteorological and Environmental Prediction (Dorval, Québec) to be the DFO hub for the application of operational ice-ocean prediction systems. One of its missions is to support real-time monitoring and analysis. SeDOO has notably undertaken the management and the update of the verification and evaluation tools based on the Class 4 metrics defined by GODAE OceanView (GOV) for Sea Surface Temperature (SST), Sea Level Anomaly (SLA), temperature and salinity profiles and sea ice concentration. The analysis and forecasts of the Global Ice-Ocean Prediction System (GIOPS) are near real-time evaluated against observations and compared with other models that participate in the GOV international benchmarking. The Class 4 metrics are also calculated for the new Regional Ice-Ocean Prediction Systems (RIOPS), whose the geographical domain covers the North Atlantic, the Arctic and the North-East Pacific. Statistics of the difference between the observations and the “model equivalents” are calculated into various sub-areas allowing to better assess the quality of the GIOPS and RIOPS forecasts and their skills in key regions of interest for Canada, such as the North-East Pacific, the North-West Atlantic or the Canadian Arctic. This is necessary to guide and enhance operational model uses in those areas. This presentation will focus on those regional comparisons of the Class 4 verifications of the CONCEPTS systems.

Session: 2010362 Coastal Oceanography and Inland Waters - Part 3
L’océanographie côtière et les eaux intérieures - Partie 3 02/06/2020 14:15

ID: 10331 Contributed abstract

Revisiting the dependence of sea surface roughness on wind speed and sea state

Shangfei Lin [1] , *Jinyu Sheng* [2]

[1]
[2]

Presented by / Présenté par: ***Shangfei Lin***
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Accurate representation of wind stress is important for numerical modelling of oceanic processes, particularly under extreme weather conditions. The effect of sea state on the wind stress is usually parameterized by relating the equivalent sea surface roughness to the wave age or wave steepness. In this study, we present a new parameterization for the dependence of sea surface roughness on the wind speed and sea state based on observations. The analyses of observations demonstrate that the sea surface roughness is correlated with the wave age stronger than the wave steepness. As a result, the wave-dependent sea surface roughness is parameterized in terms of the wave age in the new parameterization. The new parameterization features that younger waves have larger drag coefficients under wind -dominated sea states and older waves can have larger drag coefficients under swell -dominated sea states. The drag coefficient predicted by the new parameterization is overall enhanced at low winds and tends to level off at high winds. The applicability of the new parameterization of the drag coefficient is investigated using a nested-grid wave model based on WAVEWATCH III. Wave model results during the March 2014 nor'easter over the northwest Atlantic Ocean are compared with the available measurements from in-situ buoys and satellite altimeters. Our analysis demonstrates that the new parameterization reduces underestimations of significant wave heights (SWHs) at low winds (or old waves) and overestimations of SWHs at moderate and high winds (or young waves) made by three existing parameterizations. Overall, the new parameterization performs the best in predicting SWHs during the winter storm.

Session: 2010363 Coastal Oceanography and Inland Waters - Part 4
L'océanographie côtière et les eaux intérieures - Partie 4 02/06/2020 15:00

ID: 10562 Contributed abstract

Climate Variability and Trends of Coastal Currents off Atlantic Canada from Satellite Altimetry

Guoqi Han [1] , *Nancy Chen* [2]

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Presented by / Présenté par: ***Guoqi Han***
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Climate variability and trends of coastal currents off Atlantic Canada are studied using along-track satellite altimetry data. The objective is to explore the potential of coastal altimetry for assessing inter-annual and decadal-scale variability of the coastal currents. Barotropic geostrophic transport anomalies were derived from TOPEX/Jason data for the period 1993 -2016. The satellite -based results are compared with those from a coupled ocean-ice model. Reasonable agreement between satellite and modelled transports is found at interannual time scales during the study period. In the Strait of Belle Isle there is strong relationship between the model transport through the transport and the along-strait sea level difference, which is than used to infer the transport from the altimetric sea level difference.

ID: 10529 Contributed abstract

Model simulated freshwater transport along Labrador Current east of Grand Banks of Newfoundland

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Presented by / Présenté par: ***Yongxing Ma***
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Using the Global Ocean Physical Reanalysis 1/12 degree data (GLORYS12), the freshwater transport (FWT) by Labrador Current (LC) at eastern of Grand Banks of Newfoundland (GBN) is investigated. The 26-year mean FWT quantifies the main path of the FWT by LC is on the eastern shelf break of GBN.
The major part of the freshwater carried by LC leaks into the Atlantic interiors through mean advection, i.e. retroflection, or eddy export, and a small portion of freshwater can westerly pass through the tail of GBN.On both seasonal and inter-annual time scales, the FWT by LC exhibits distinct variability.
This study reveals the roles of horizontal velocity and salinity in affecting the variability of the FWT.
The velocity variations of LC affects the FWT in the whole region of LC, while the salinity variations only influence FWT variability in the area to the north of 45\degree N.

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ID: 10313 Contributed abstract

Characteristic evolution of the Atlantic Meridional Overturning Circulation from 1990 to 2015: an eddy-resolving ocean model study

zeliang Wang [1] , *Dave Brickman* [2] , *Blair Greenan* [3]

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Presented by / Présenté par: ***zeliang Wang***
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A 1/12 degree North Atlantic model is used to investigate the Atlantic Meridional Overturning Circulation (AMOC) variability from 1990 to 2015. The seasonality of the AMOC in depth and density spaces is

dominated by the Ekman transport from low to high latitudes. At interannual timescales, the AMOC in depth and density spaces has different characteristics, mostly in high latitudes, which is attributed to strong doming of isopycnals. An Empirical Orthogonal Function analysis of the AMOC in depth space demonstrates that the AMOC can be decomposed into two portions – one associated with Labrador Sea winter convection and one related to Ekman transport. The Ekman transport portion of the depth-space AMOC has a general out-of-phase relationship between high and low latitudes and the AMOC becomes more meridionally coherent after the Ekman transport portion is removed. Our study suggests that the AMOC in depth space appears to have two regimes, a strong one before 2001, and a weak one after 2001, which is seen to be associated with the westward movement of the winter North Atlantic Oscillation centers of action starting from 2001. The two-regime behavior is best reflected in the variability of the western part of the Labrador Current, while the general decline over this period is also seen in the Labrador Sea convection depth, the strength of the eastern part of the Labrador Current, and the downward movement of isopycals in the deep layers of the Labrador Sea The latter suggests that hydrographic changes in Labrador Sea deep layers could be potentially used as a proxy for AMOC variability.

Session: 2010363 Coastal Oceanography and Inland Waters - Part 4
L'océanographie côtière et les eaux intérieures - Partie 4 02/06/2020 15:45

ID: 10231 Contributed abstract

Changes in the circulation pattern in the Northwest Atlantic: Impact on the deoxygenation of the deep waters in the Lower St. Lawrence Estuary

Mathilde Jutras [1] , *Carolina Dufour* [2] , *Alfonso Mucci* [3] , *Frédéric Cyr* [4] , *Denis Gilbert* [5]

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Presented by / Présenté par: ***Mathilde Jutras***
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Over the past decades, the deep waters of the Lower St. Lawrence Estuary underwent a strong deoxygenation, with oxygen concentrations dropping by half and reaching hypoxic levels by the mid-1980s. The deoxygenation is partly due to a change in the inflow of waters from the Northwest Atlantic that enter the Laurentian Channel (LC), a deep channel that runs from the continental shelf break to the head of the Lower St. Lawrence Estuary. The deep waters of this channel are formed from a mixture of cold, oxygen-rich Labrador Current waters (LCW) and warm, oxygen-poor North Atlantic Central waters (NACW) carried by the Gulf Stream. They mix on the continental shelf and enter the Gulf and St. Lawrence Estuary as they flow through Cabot Strait.

We reconstructed a time series of the relative contribution of LCW and NACW to the deep waters of the LC over the last two decades, using an extended optimum-multiparameter (eOMP) analysis of in situ observations of water properties. The analysis reveals that while the fractions of LCW and NACW

were relatively invariant between the 1990s and early 2000s, a strong decline in the relative contribution of LCW followed starting in 2008. The temporal evolution of the relative contributions of the two water masses is characterized by a weak inter-annual variability and a strong multi-annual – likely decadal – variability.

We find that, over the last two decades, the strength of the Labrador Current was a more important factor in modulating the origin of deep waters entering the LC than the strength or location of the Gulf Stream, consistent with a reduction in the westward transport of LCW west of the Tail of the Grand Banks. In spite of our limited time series, results of the eOMP analysis also highlight a multi-year variability that was not visible in long-term trends previously inferred from multi-annual averages.

Session: 2010363 Coastal Oceanography and Inland Waters - Part 4
L'océanographie côtière et les eaux intérieures - Partie 4 02/06/2020 16:00

ID: 10489 Contributed abstract

Predicting Internal Solitary Waves in the Gulf of Maine

Hui Shen [1] , *William Perrie* [2] , *Catherine Johnson* [3]

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Presented by / Présenté par: ***Hui Shen***
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Internal solitary waves (ISWs) are important physical processes in the Gulf of Maine (GoM), which is one of the most productive ecosystems of the Northwest Atlantic. In order to understand the roles that ISWs play, it is necessary to have synthesized knowledge of their timing and distributions. We detail the ISW spatial distribution patterns in the GoM using modern high resolution satellite imagery. A prediction methodology is suggested based on the speed of mode-1 ISWs, which is cross- validated using three methods: Remote sensing based on positional displacements of ISWs strips in continuous images, theoretical analysis based on climatological ocean stratification, and an empirical method based on bathymetry. Prediction accuracy is further validated by independently collected high spatial resolution satellite images from multiple sensors. We found a new generation site for ISWs near Grand Manan, with wave crests extending over the entire GoM. Interference of ISWs originating from the new generation site and the well-known generation location on Georges Bank, plus local-scale ISW generation sites, creates cross – sea conditions within the water column, resulting in complex ISWs. We find that the background barotropic currents do not significantly influence the ISW spatial distributions, which simplifies the prediction of ISWs; we also consider the influence of tidal currents, general circulation, and stratification. This methodology is potentially useful for additional studies, for example linking ISWs, energy and nutrient budgets, mixing and primary production in the Gulf of Maine.

ID: 10584 Contributed abstract

The planetary beta-effect on the vertical structure of a coherent vortex

Shengmu Yang [1] , *Jiuxing Xing* [2] , *Jinyu Sheng* [3] , *Shengli Chen* [4] , *Jiwei Tian* [5] , *Daoyi Chen* [6]

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Presented by / Présenté par: ***Shengmu Yang***
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The influence of the planetary beta-effect on the vertical structure of a coherent eddy is investigated in this study based on analytical considerations and numerical results produced by the MIT General Circulation Model (MITgcm). Both the analytical and numerical results demonstrate that, during the westward propagation of a mesoscale eddy, the momentum advection and divergence in the inner region of the eddy impact the propagation direction of the eddy on a beta plane. In the upper layer of the mesoscale eddy, the eddy propagation is mainly controlled by the beta-effect and nonlinear effect (momentum advection). In the lower layer of an anticyclonic eddy, the eddy propagation direction is dominated by the advection and divergence, which leads to the westward shift of the eddy centre in the upper layer. For a cyclonic eddy, by comparison, the vertical axis tilts to eastwards from surface to bottom. The tilting distance is up to 30 km in a flat bottom ocean with the beta value of 2.15×10^-11 m^-1s^-1. In addition, model results indicate that vertical stratification, eddy strength, and rough topography have significant influences on the vertical structure of a mesoscale eddy.

Day 7 - 3 June 2020

2010030 Atmosphere, Ocean, and Climate Dynamics - Part 1

Convenors: Ron McTaggart-Cowan, Marek Stastna, Michael Waite, Adam Monahan

This session combines submissions that document studies of the dynamics of the atmosphere, oceans and/or climate system. The scope of the session is deliberately broad in order to include research that spans a broad range of spatial and temporal scales. Studies of the dynamics of mesoscale processes that act on hourly timescales are as welcome in this session as those that document the evolution of planetary-scale structures in a changing climate. Such investigations may include diagnoses and theoretical studies of forecast, climate, and process models, or studies based on reanalysis and other observational datasets; however, any topic that is relevant to atmosphere, ocean, or climate dynamics will fit well into this session.

ID: 10238 Contributed abstract

Instability and cross-boundary-layer transport by shoaling internal waves over realistic slopes

Chengzhu Xu [1] , *Marek Stastna* [2]

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Presented by / Présenté par: ***Chengzhu Xu***
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Internal solitary waves play an important role in mixing and sediment resuspension in stratified fluids, primarily through various instabilities and wave breaking mechanisms. When shoaling into shallow waters, waves of depression may either fission into a packet of waves of elevation over mild slopes or break over steep slopes. The fission process is generally considered less violent than wave breaking, since very little turbulent mixing or energy dissipation occurs during this process. In the present work, however, we found that this is not always the case. Using high-resolution numerical simulations performed in a domain representing a tilted laboratory tank, we found that boundary layer instability in the form of a separation bubble occurs during the fission process. The separation bubble is generated beneath the wave of elevation that emerges from the fission process, and is vitally influenced by currents induced by the leading wave of depression. As the waves shoal further, the growth and break down of the separation bubble leads to significant cross-boundary-layer transport and diapycnal mixing. The results suggest that the fission process, which occurs over a considerable geographical region in the ocean, can be as efficient as wave breaking when it comes to cross-boundary-layer transport.

ID: 10260 Contributed abstract

Volumetric heating models and their impact on small scale, non-hydrostatic dynamics

Andrew Grace [1] , *Andrea Scott* [2] , *Marek Stastna* [3] , *Kevin Lamb* [4]

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Presented by / Présenté par: ***Andrew Grace***

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Solar radiation is an extremely important factor in geophysical fluid dynamics as it is a major mechanism by which heat is introduced into the flow. The motivation for this research is to understand the role of penetrative radiation in heating shallow bodies of water that experience seasonal ice cover. Focus will be on the impact of radiation on small scale dynamics during the shoulder seasons (spring and fall), with the long-term objective of assessing the shallow western basin of Lake Erie. Penetrative solar radiation, often referred to as "short wave radiation" is parameterized as a body forcing term in the equation for the temperature of the fluid. The magnitude of the forcing decays exponentially with depth following a Beer-Lambert law formulation, but often at different rates to account for different bands of light. In this talk, I will describe the functional form of the short wave radiation and its shortfalls in the MITgcm. Then I will describe how the simple model included with the MITgcm can be improved to account for bottom reflection. In a shallow body of water, the effects of bottom radiation become important because a significant proportion of the incident radiation arrives and is reflected off the bottom. I will then demonstrate the impact that bottom reflection has on the dynamics via a series of simulations of a lock release experiment. The initial temperatures of the lock release problem will be below the density maximum of freshwater, so a positive heat flux has a destabilizing effect, thus, the non-hydrostatic capabilities of the model are required.

Session: 2010030 Atmosphere, Ocean, and Climate Dynamics - Part 1
La dynamique de l'atmosphère, des océans et du climat - Partie 1 03/06/2020 13:35

ID: 10394 Contributed abstract

Centrifugal Instability of a Geostrophic Jet

Francis Poulin [1] , *Matthew Harris* [2] , *Kevin Lamb* [3]

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Presented by / Présenté par: ***Francis Poulin***
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Oceanic and Atmospheric jets with sufficiently strong anticyclonic vorticity are subject to centrifugal instabilities. This mechanism is relatively fast in comparison to barotropic and baroclinic instabilities and require non-conservative forces that mix the fluid properties. In this work, we present a novel approach to compute the linear stability characteristics of both barotropic and baroclinic jets. This enables us to compute the growth rates and spatial structures very accurately and efficiently. Subsequently, by integrating the fully nonlinear, non-hydrostatic dynamics using the spectrally accurate numerical model SPINS, we validate the predictions of the linear theory and then investigate the nonlinear equilibration that results. Depending on the Reynolds number of the flows, there are instances where a secondary instability occurs that eventually produces vortical structures, some of which are themselves subject to centrifugal instabilities. This idealized investigation quantifies the effects of centrifugal instabilities as an

initial step to determine how to parameterize them.

Session: 2010030 Atmosphere, Ocean, and Climate Dynamics - Part 1
La dynamique de l'atmosphère, des océans et du climat - Partie 1 03/06/2020 13:50

ID: 10380 Contributed abstract

The Dynamics of the Beaufort Gyre

Elizabeth Webb [1] , *Francis Poulin* [2] , *Mary-Louise Timmermans* [3]

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[3] Yale University

Presented by / Présenté par: ***Elizabeth Webb***
Contact: eawebb@uwaterloo.ca

The Beaufort Gyre is located in the Canadian Arctic and is responsible for the dominant circulation of the Beaufort Sea. This Gyre currently flows in a clockwise direction and collects fresh water from melting sea ice. However, every 5 - 7 years it has been observed to reverse direction and release the collected fresh water into the Northern Atlantic. The last recorded reversal was over 20 years ago. Currently, the Beaufort Gyre holds as much fresh water as all the great lakes combined. When the next reversal happens, it is predicted that the fresh water will be released and then act as a thick, cold blanket over the Northern Atlantic Ocean, preventing heat transferred to the atmosphere, and greatly affecting the European climate and fisheries.

This research focuses on better understanding the dynamics of the Beaufort Gyre in order to gain insight in the transport of heat and melting of the sea ice above. We idealize the Beaufort Gyre in the context of the Quasi-Geostrophic model, where we account for the rotation of earth, wind forcing and bottom drag. Using the finite element library, Firedrake, we compute steady solutions for the Beaufort Gyre and examine how the structure of the gyre depends on the varying strength of the winds. Subsequently, we investigate the stability characteristics of the gyre. The purpose of this work is to investigate the turbulent eddy field that is generated as a result of shear instabilities, how this affects the distribution of heat in the vertical direction and the subsequent impact on the melting of the sea ice above.

Session: 2010030 Atmosphere, Ocean, and Climate Dynamics - Part 1 La dynamique de l'atmosphère, des océans et du climat - Partie 1 03/06/2020 13:55

ID: 10413 Contributed abstract

Simulating radiation driven, nonhydrostatic flow with incomplete ice cover

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Donovan Allum [1], *Andrew Grace* [2], *Marek Stastna* [3]

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Presented by / Présenté par: ***Donovan Allum***
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The point where ice cover on a lake falls below a threshold is often called the breakup date. At this point, the ice which may have covered the entire surface during the winter has broken up and disintegrated into ice sheets or floe. This leads to discrete changes in albedo on the surface of the lake, causing, amongst other things, water under-ice to warm at a slower rate. This may in turn drive both vertical and horizontal motions, leading to enhanced rates of mixing.

We use a non-hydrostatic pseudospectral model, known as SPINS, to simulate a small, two-dimensional subset of a lake with a single floe at the centre of the surface with extremely fine resolution. The presence of ice decereases the solar forcing in the centre of the lake. In this talk, we analyze the motions and mixing driven by the difference in forcing under and outside the floe. The simulations will include a variety (in type and strength) of initial stratifications. Implications for basin scale models will be discussed.

Session: 2010030 Atmosphere, Ocean, and Climate Dynamics - Part 1
La dynamique de l'atmosphère, des océans et du climat - Partie 1 03/06/2020 14:00

ID: 10296 Contributed abstract

Double Diffusive Instability Effects on Internal Seiches

Nicolas Castro-Folker [1], *Marek Stastna* [2]

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Presented by / Présenté par: ***Nicolas Castro-Folker***
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Internal Seiches have been widely observed in lakes during the stratified season. They have also provided fruitful ground for experimentalists and numerical modellers. Large amplitude internal seiches can lead to shear instability and wave breaking, both of which lead to irreversible mixing. When the density stratification is due to temperature and a solute (e.g. salt) double diffusive instabilities present an alternative means by which the internal wave guide is degraded. We present high resolution simulations of experimental scale internal seiches in the presence of double diffusion. We discuss the implications of the very large Schmidt numbers typical for salt, and demonstrate that double diffusive instabilities can coexist with both standing-wave-type internal seiches and internal seiches that break down into nonlinear, dispersive wave trains. We characterize viscous dissipation

in the simulations, finding that while the vigorous double diffusive instabilities are important for viscous dissipation, the shear associated with the seiche cannot be neglected. Finally, we comment on the possibility of scaling up to the field scale.

Session: 2010030 Atmosphere, Ocean, and Climate Dynamics - Part 1
La dynamique de l'atmosphère, des océans et du climat - Partie 1 03/06/2020 14:05

ID: 10356 Contributed abstract

Simulating Wintertime Convection Dynamics Using the MITgcm Ice Model

Sarah Walsh [1] , *Marek Stastna* [2] , *Kevin Lamb* [3] , *Andrea Scott* [4] , *Senja Walberg* [5]

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Presented by / Présenté par: ***Sarah Walsh***
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Lake Erie is an important source of drinking water, a location for recreational activities and a haven for unique ecosystems (e.g. Point Pelee). Recent research has suggested that some wintertime processes are significantly increasing amounts of hypoxic water and harmful algal blooms found in the lake during the following summer. Much of the mixing in Lake Erie is caused by wind forcing. Mixing also occurs via an unstable water column that results from incoming solar radiation when water is below the temperature (around 4 degrees) at which the maximum density occurs.

We report on idealized simulations using the MITgcm (Massachusetts Institute of Technology General Circulation Model). The MITgcm is a 3D ocean model with the ability to model sea ice. We will use the model to create high resolution (1m and 10m) toy simulations where we add an ice cover to parts of a small, idealized rectangular lake and observe the mixing and circulation that results for different ice distributions and forcing conditions. We will also compare cases with the model set to be non-hydrostatic, with ones for which it is hydrostatic. Special attention will be paid to mixing that occurs near the ice edge.

Session: 2010030 Atmosphere, Ocean, and Climate Dynamics - Part 1
La dynamique de l'atmosphère, des océans et du climat - Partie 1 03/06/2020 14:10

ID: 10242 Contributed abstract

Bispectral Unfolding of the Skewness of Correlated Additive and Multiplicative Noise Processes

Adam Monahan [1]

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Presented by / Présenté par: ***Adam Monahan***
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Correlated additive and multiplicative (CAM) noise processes are well-established as general “null hypothesis” models of non-Gaussian variability in atmospheric and oceanic quantities. In this study, analytic expressions for the bispectral density (which partitions the third statistical moment into triad frequency interactions in a manner analogous to the partitioning of variance by the spectral density) are developed for discrete and continuous-time CAM processes. It is then demonstrated that under lowpass filtering, while the absolute skewness of a discrete-time CAM process may increase or decrease with decreasing cutoff frequency, the absolute skewness of continuous-time CAM processes decreases monotonically. This second result provides a test to assess the degree to which an observed time series is consistent with continuous-time CAM dynamics.

2010031 Atmosphere, Ocean, and Climate Dynamics - Part 2

Convenors: Ron McTaggart-Cowan, Marek Stastna, Michael Waite, Adam Monahan

This session combines submissions that document studies of the dynamics of the atmosphere, oceans and/or climate system. The scope of the session is deliberately broad in order to include research that spans a broad range of spatial and temporal scales. Studies of the dynamics of mesoscale processes that act on hourly timescales are as welcome in this session as those that document the evolution of planetary-scale structures in a changing climate. Such investigations may include diagnoses and theoretical studies of forecast, climate, and process models, or studies based on reanalysis and other observational datasets; however, any topic that is relevant to atmosphere, ocean, or climate dynamics will fit well into this session.

Session: 2010031 Atmosphere, Ocean, and Climate Dynamics - Part 2
La dynamique de l’atmosphère, des océans et du climat - Partie 2 03/06/2020 15:00

ID: 10455 Contributed abstract

Extreme extratropical cyclogenesis processes along coastal regions of North America: 1979-present

John Gyakum [1]

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Presented by / Présenté par: ***John Gyakum***
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Explosive extratropical cyclogenesis is generally accepted as primarily a cold-season, maritime process that has been the subject of extensive research during the past 40 years.
Our objective is to gain an improved understanding of the temporal changes in this phenomenon from 1979 through the present in a background of global warming. We quantitatively analyze background thermodynamic and dynamic environments during the full life cycle of rapid cyclogenesis during the

Northern Hemisphere cold season of December, January and February. In particular, we assess the role that warming air masses have in modulating explosive extratropical cyclogenesis for the western North Atlantic and eastern North Pacific basins.
Documentation of the cyclogenesis processes is obtained with the 6-hourly manually analyzed surface maps of the Northern Hemisphere, along with the National Centers for Environmental Prediction (NCEP) Climate Forecast System Reanalysis and the NCEP Global Ensemble Forecast System (GEFS) reforecasts.
By using the unique combination of this surface cyclone dataset and the high-resolution global reanalysis, we examine the modulation of explosive cyclogenetic processes by the observed poleward intrusions of tropical air masses. The consequences of such intrusions include a reduction in the effective static stability that increases the strength of the secondary circulation response to a given strength of forcing (such as mid-tropospheric cyclonic vorticity advection), in addition to the nonlinear feedbacks on precipitation rate for air masses characterized by higher equivalent potential temperatures.

We find that increased intensification occurs with increasing 850-hPa θe values, and the possibility of the crucial importance of elevated moist convective processes.
An analysis of GEFS reforecasts of explosive intensification show strong performance at both 12-36 and 24-48 h, though the largest errors are associated with poleward intrusions of maritime, tropical air masses.
This research provides quantitative guidance on the role that warming air masses have in modulating explosive extratropical cyclogenesis.

Session: 2010031 Atmosphere, Ocean, and Climate Dynamics - Part 2
La dynamique de l'atmosphère, des océans et du climat - Partie 2 03/06/2020 15:15

ID: 10346 Contributed abstract

Where does the energy from latent heating in the atmosphere go?

Robert Fajber [1] , *Paul Kushner* [2]

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Presented by / Présenté par: ***Robert Fajber***
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In the tropics and storm tracks latent heating is much larger than the longwave cooling in the same region. This implies that there must be a transport of warm air masses from these regions to regions of cooling. Our study quantifies this transport in an idealized aquaplanet model by using a passive tracer method. The method emits tracers where latent heating occurs, and removes tracer where there is long wave cooling, allowing us to partition the potential temperature between the different physical processes which heat the atmosphere.

We find that there the warm air masses created through tropical convection and latent heating in baroclinic eddies extend throughout the entirety of the troposphere. In particular, in the high latitudes where there is almost no latent heating in the model, the contribution to the potential temperature from latent heating is between 50% and 70%. We find that a significant amount of midlatitude

temperature variability can be related to latent heating in the tropics. We can also investigate the way heating and transport processes are affected by global warming. Under CO2 doubling,the contribution to potential temperature from latent heating increases, even in regions where there latent heating is no occurring, with increased polewards transport. Our results show the promise of this technique for climate studies and model development.

Session: 2010031 Atmosphere, Ocean, and Climate Dynamics - Part 2
La dynamique de l'atmosphère, des océans et du climat - Partie 2 03/06/2020 15:30

ID: 10245 Contributed abstract

Ensemble predictability of a major freezing rain event in Montreal

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Presented by / Présenté par: ***Daniel Tootill***
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Regions of eastern Canada, including Newfoundland and the St Lawrence River Valley, Quebec, see relatively frequent occurrences of freezing rain which can lead to dangerous road conditions and damages to power line infrastructure. An accurate forecast of the winter precipitation type is crucial to allow stakeholders to undertake appropriate countermeasures to minimize disruptions and losses. However, forecasting the correct precipitation type (particularly freezing rain and ice pellets) in winter precipitation events is still subject to large uncertainties and often proves inaccurate, since the temperature range encompassing rain, freezing precipitation and snow can be comparable to the error of numerical weather forecast models. Furthermore, efforts to physically understand the mechanisms generating uncertainty in precipitation type are often challenged by interacting dynamical processes across multiple scales.

To further the understanding of the origins of errors in winter precipitation events, we conduct high-resolution (3 km) ensemble forecasts of a major freezing rain event in 2017 in Montreal. This event is notable due to a poor short-range forecast provided by Environment Canada. One day prior, ECCC issued a Snowfall Warning as precipitation was predicted to fall primarily as snow. The ensemble, initialized approximately 36h before the onset of heavy precipitation, exhibits a relatively large spread in precipitation type, with members varying from virtually all snow to all freezing rain over Montreal during the period of heaviest precipitation. This nor'easter event was characterized by a surface cyclone paralleling the US mid-Atlantic coast, resulting in heavy precipitation and pressure-driven northeasterly winds at Montreal. Using ensemble sensitivity analysis and compositing, the key dynamical mechanisms underlying the forecast error and generating ensemble spread are identified. This analysis considers the sensitivities of precipitation type not only to the concurrent atmospheric state but also to the ensemble initial conditions, thereby pointing to areas in need of greater observational coverage.

ID: 10230 Contributed abstract

Case study of a polar low simulated with the Canadian Regional Climate Model (CRCM6)

Marta Moreno Ibáñez [1] , *René Laprise* [2] , *Philippe Gachon* [3]

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Presented by / Présenté par: ***Marta Moreno Ibáñez***
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Polar lows are high-latitude mesoscale weather systems associated with severe weather such as gale-force winds and heavy snow showers. Therefore, they pose a threat to coastal communities, marine transportation and oil and gas platforms.

Polar low forecasting has long remained a challenge due to the small size and short lifetime of these systems. Nevertheless, the representation of polar lows in numerical models has significantly improved with the advent of high-resolution atmospheric models. As a result, these atmospheric models have become a powerful tool to analyse the development mechanisms of polar lows.

In this work, we conducted a case study of an observed polar low that developed in the winter season of 2019. The polar low was simulated with the developmental version of the convection permitting Canadian Regional Climate Model (CRCM6). A high-resolution simulation (2.5 km grid) was driven by ERA5 reanalysis. The model was initialised at different times to evaluate the impact of different initial conditions on the representation of the polar low. First, the results of the simulation that better captures the polar low development are compared to observational data in order to assess the skill of the model at reproducing the characteristics of the observed polar low. In particular, the results are compared to IR satellite imagery and scatterometer wind estimates to analyse if the location and intensity of the simulated polar low are similar to those of the observed one. Second, the simulated fields are analyzed in order to better understand the role that different mechanisms play in the formation and intensification of this polar low. Particular attention will be given to surface sensible and latent heat fluxes as well as to the temperature profile at the polar low location.

ID: 10428 Contributed abstract

Sediment Resuspension and Transport by Bolus Propagation over a Mild Slope

Amin Ghassemi [1] , *Saeid Zahedi Vahid* [2] , *Leon Boegman* [3]

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Presented by / Présenté par: ***Amin Ghassemi***
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Breaking of internal solitary waves (ISWs), over boundary slopes in stratified lakes and coastal oceans, plays a significant role in controlling density stratification, vertical biogeochemical fluxes and also sediment resuspension and transport on continental margins. The mechanisms driving sediment movement depends on the characteristics of both the wave and the slope. Breaking of ISWs by fission occurs over extremely mild slopes, which are characteristic of the continental shelf; however, mild slopes have rarely been investigated in laboratory work due to limitations of experimental setups. Fission produces boluses that are like trapped core vortices moving shoreward and are assumed to be a key driver of sediment movement on the continental shelf or upper slope. In the present laboratory study, sediment movement by the action of boluses results from ISW fission over an extremely mild slope. Experiments are in a two-layer medium with continuously generated non-linear ISWs. Bedform formation and evolution, in addition to sediment resuspension, by the action of boluses are investigated and the characteristics are compared with observations from the ocean to better understand the mechanisms driving sediment movements over realistic slopes in oceans and lakes.

Session: 2010031 Atmosphere, Ocean, and Climate Dynamics - Part 2 La dynamique de l'atmosphère, des océans et du climat - Partie 2

03/06/2020 16:05

ID: 10329 Contributed abstract

Mechanism of Interannual Cross-equatorial Overturning Anomalies in the Pacific Ocean

Devanarayana Rao Mohan Rao [1] , *Neil Tandon* [2]

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Presented by / Présenté par: ***Devanarayana Rao Mohan Rao***
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A recent study (Tandon et al., J. Phys. Oceanogr., 2020) has shown that interannual variability of the global meridional overturning circulation (MOC) is dominated by the Pacific MOC, and this variability is characterized by a prominent cross-equatorial cell (CEC) spanning the tropics. This CEC is a potentially important influence on interannual climate variability, but the mechanism responsible for the CEC is not understood. In this study, we investigate the CEC mechanism using version 4.2 of the Estimating the Circulation and Climate of the Ocean (ECCO) state estimate. Our analysis shows that the CEC is driven by the following mechanistic chain: 1) Interannual anomalies of meridional wind stress generate temperature anomalies near the equator. 2) These temperature anomalies, in turn, generate equatorially antisymmetric anomalies of sea surface height (SSH). 3) These SSH anomalies drive cross-equatorial flow in the upper Pacific Ocean (above approximately 1000 m). 4) This anomalous cross-equatorial flow in the upper Pacific drives compensating flow in the deep Pacific. This mechanism contrasts with that responsible for anomalous cross-equatorial overturning on seasonal timescales, which is primarily the Ekman response to equatorially antisymmetric anomalies of zonal wind stress (Jayne and Marotzke, Rev. Geophys., 2001). On interannual timescales, however, the zonal wind stress anomalies associated with the CEC are equatorially symmetric (rather than antisymmetric), and steric SSH variations are the dominant driver of the CEC.

Session: 2010031 Atmosphere, Ocean, and Climate Dynamics - Part 2
La dynamique de l'atmosphère, des océans et du climat - Partie 2 03/06/2020 16:15

ID: 10544 Contributed abstract

Tidal effects measured within inland water-bodies of the Yucatan Peninsula

Aaron Coutino [1] , *Marek Stastna* [2] , *Chelsi McNeill-Jewer* [3] , *Eduard Reinhardt* [4]

[1] University of Waterloo
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[4] McMaster University

Presented by / Présenté par: ***Aaron Coutino***
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We report on a series of high resolution water depth measurements from various natural water bodies throughout the Yucatan Peninsula, Mexico. The sensors measured water level every 30 minutes for six months. Across all locations, diurnal and semi-diurnal oscillations were measured with amplitudes well above theoretical levels. For verification as to the nature of these oscillations, we computed the wavelet coherence of our inland records with a coastal lagoon sensor and observed in-phase coherence at both the diurnal and semi-diurnal periods. Furthermore, individual tidal constituents near 24 hours, 12 hours, 6 hours, and 4 hours were observed. To test the significance of the oscillations an AR(2) model of the water depth was created and 95% confidence intervals were calculated. Both the diurnal and semi-diurnal spectral peaks are above this level. These results indicate that there is a hydrological connection between these inland water bodies and the ocean as they are individually too small to generate tides themselves. Furthermore, the presence of tidal oscillations in lakes and sinkholes that have previously been thought to be hydrologically isolated has major implications for studies in the region. Previous

paleoclimate reconstructions from lakes in the region have explicitly assumed closed waterbodies and used this in the interpretation of the reconstruction. This result also has significant impacts for water quality changes inland to water quality of the coastal ocean.

Day 8 - 4 June 2020

Convenor: Gordon McBean

The global climate is changing, and Canada is warming at about twice the rate of the planet. The World Economic Forum 2020 Global Risk Report, for the next 10 years, ranked extreme weather events and climate action failure to mitigate and adapt as two of the most likely and impacting risks. In addition, all WEF reports over the past decade have identified water crises, food and human security as risks of highest concern into the future. To reduce the impacts on Canadians and all societies there is need to address these issues through interdisciplinary and climate research to inform the development of resilient societies. This session will have presentations on the extreme events in the future climate and an example of fundamental science on greenhouse effects. Presentations will address the need to understand our interactions with the natural environment including water and ecosystem services, and how the knowledge of Indigenous and Western science can work together to effectively address these issues. The importance of ensuring that Canadian National Climate Archives preserve reliable historical records and provide better access to and the communications of climate information and how the utilization of novel methods like machine learning that use new sources of data like social media can enhance weather and climate communication will be examined in other presentations. As the extreme events increase, there is need to go from risk to resilience and use science to build resilient communities. In addressing these issues effectively, estimates of the costs of climate change for Canada and a Canadian perspective on achieving net zero emissions and impacts are essential. The Session will provide interesting and varied scientific perspectives on Building Societal Resilience to Changing Weather, Climate and Environment, the overall theme of CMOS Congress 2020.

Session: 2010350 Interdisciplinary and climate research on resilience - Part 1 Recherche interdisciplinaire et climatique sur la résilience - Partie 1

04/06/2020 11:05

ID: 10265 Contributed abstract

Extremes in the future climate

Francis Zwiers [1] , *Chao Li* [2] , *MA Ben Alaya* [3] , *Xuebin Zhang* [4]

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[2]
[3]
[4]

Presented by / Présenté par: ***Francis Zwiers***
Contact: fwzwiers@uvic.ca

The primary focus of this talk will be precipitation extremes in the future climate, a phenomenon that produces very large impacts, is the subject of intense research activity, and for which the body of knowledge is still growing rapidly. The talk will consider the future from several angles, beginning with an overview of projected changes directly from Earth system models participating in CMIP6 using the

new Shared Socioeconomic Pathway forcing scenarios. Globally, it is found that short duration extremes intensify at roughly the Clausius-Clapeyron rate of ~7% per °C of warming, independently of the climate sensitivity of the model and the forcing scenario. It is also seen that the rate of intensification is greater for rarer events, producing an “intense gets intenser” phenomenon. Secondly, we will consider whether different types of temperature scaling based on observations of the historical period can inform the future and whether there is evidence that dynamics alters those relationships. We find that not all scaling approaches are suitable, and that very large samples of data – much larger than typically available from instrumental records – are required for those that are suitable. The decomposition of scaling factors into thermal and dynamic components shows that circulation change plays in role in producing the “intense gets intenser” phenomenon. Research on precipitation extremes often relies on tools from extreme value theory, and thus finally, using a different notion of the “future”, we very briefly consider their performance in estimating very long period return levels. Performance is often less than ideal due to surprises that may exist in parts of the upper tail of the precipitation distribution that are poorly sampled. More complex approaches that incorporate more of our understanding of the physical processes responsible for extreme precipitation improve performance.

Session: 2010350 Interdisciplinary and climate research on resilience - Part 1 Recherche interdisciplinaire et climatique sur la résilience - Partie 1

04/06/2020 11:30

ID: 10587 Contributed abstract

Ohneganous: Water as the first environment.

Dawn Martin-Hill [1]

[1] McMaster University

Presented by / Présenté par: ***Dawn Martin-Hill***
Contact: gmcbean@uwo.ca

The warning by the Intergovernmental Panel on Climate Change (IPCC), wherein lead scientists worldwide reiterated the emergency (< 12 years to limit increasing temperatures to 1.5 C) we all face as a humanity. The key trends projected by global climate reports and national climate projects, tend to either overlook or relatively under reflect the trends of climate variations for areas held or managed by Indigenous peoples in Canada and elsewhere in the world. A Traditional Ecological Knowledge and western science GWF team co-created a modal of mixed methods creating modelling, water quality data, sensors and tools designed for adaptation planning. The Co-Creation project makes a ‘reference case’ for mainstreaming Indigenous people in global sustainability planning is impactful and innovative. Developing modelling, digital archives, training and virtual reality interactive knowledge centre to disseminate and share findings focus on multi-media technologies allowing for knowledge mobilization. The integrated approach adopted by the project towards building community capacity to mitigate impacts of water insecurity and climate change will advance resiliency of Indigenous communities

Session: 2010350 Interdisciplinary and climate research on resilience - Part 1 Recherche interdisciplinaire et climatique sur la résilience - Partie 1

04/06/2020 11:45

ID: 10286 Contributed abstract

Climate Change, Energy, and Net Zero: A Canadian Perspective

Charles Lin [1] , *James Lin* [2]

[1] Retired Scientist

[2] University of Alberta (Alumni)

Presented by / Présenté par: ***Charles Lin***
Contact: charles.augustin.lin@gmail.com

The Canadian federal government has committed the country to reach “net zero” anthropogenic CO2 emissions by 2050 in accord with the Paris Agreement, where emissions by sources are balanced by removals by sinks in the second half of this century. Governments, corporations and citizens have a role in this commitment; the pathways to reach it have not been defined. We outline some of the significant challenges at the country, province, city and individual levels. We focus primarily on the impacts on energy. At the individual level, actions such as driving less or eating less red meat, no matter how worthwhile, are not sufficient. These actions must be transformed to collective actions through mobilization, to influence governments, politicians, and corporations. At the city level, we review the Low Carbon Cities Canada (LC3), a federal initiative to help cities reduce carbon emissions. We also focus on how the oil and gas sector in Canada plans to deal with net zero. At the international level, we review the “Sky” Scenario developed by Shell International to reach this goal. We close with reviewing recent trends such as the concern of the central banks on climate-related financial risks, and the attention of the financial investment community on the exposure to environmental, social and governance (ESG) risks, which includes those arising from climate change.

Session: 2010350 Interdisciplinary and climate research on resilience - Part 1 Recherche interdisciplinaire et climatique sur la résilience - Partie 1

04/06/2020 12:00

ID: 10588 Contributed abstract

Estimating the Costs of Climate Change for Canada

Dale Beugin [1]

[1] Canadian Institute for Climate Choices

Presented by / Présenté par: ***Dale Beugin***
Contact: gmcbean@uwo.ca

The Canadian Institute for Climate Choices is undertaking a study to estimate the economic costs of major climate risks for Canada under high and low global emissions futures that combines process-based "bottom-up" climate impact and cost analysis and "top-down" macroeconomic analysis.

Session: 2010350 Interdisciplinary and climate research on resilience - Part 1 Recherche interdisciplinaire et climatique sur la résilience - Partie 1

04/06/2020 12:15

ID: 10226 Contributed abstract

Collaborative survey development and training to understand Inuit uses and needs for weather, water, ice and climate information

Natalie Carter [1] , *Shirley Tagalik* [2] , *Gita Ljubicic* [3]

[1] University of Ottawa
[2] Aqqiumavvik Society
[3] McMaster University

Presented by / Présenté par: ***Natalie Carter***
Contact: ncarte3@uottawa.ca

Weather, water, and ice conditions in Inuit Nunangat (Inuit homelands) have become increasingly unpredictable due to the combined effects of climate change and industrial development. Rapid social and political change has also impacted the intergenerational transfer of Inuit knowledge and subsistence harvesting practices, creating challenges for Inuit to travel safely on the land (including water and ice). Our team of 24 Inuit, northern, and southern researchers connects long-term research partnerships in 9 Nunavut, 3 Nunavik, and 6 Inuvialuit communities. For years we have been hearing that weather, water, ice, and climate (WWIC) information and services are not meeting Inuit and other northerners' local needs considering the scale, accessibility, usability, language, and technological barriers that arise for remote northern communities. At the same time, Inuit Tapiriit Kanatami's 2018 National Inuit Strategy on Research (NISR) calls for the inclusion of Inuit as partners in the governance of Inuit Nunangat research, and the development of necessary skills and confidence for Inuit to conduct research on their own, on topics of interest to them or those highlighted as priorities in their community.

Our goal in working together is to help improve the WWIC information that is available, and how it is communicated in northern communities, while creating opportunities and empowering Inuit and Northerners to be research leaders.

To accomplish this goal, we follow the Aajiiqatigingniq research framework, outlined by the Aqqiumavvik Society working with Elders from across Nunavut. This framework guides our collaborative efforts at consensus-building and decision-making. This presentation will outline the process we have taken to date involving collaborative survey development and training 17 Local Research Coordinators (LRC) who are being supported remotely while independently

facilitating questionnaires. The process of conducting collaborative survey development and co-facilitating training events led us to reflect on our approach and methodology we engaged in while undertaking those activities. Our reflections are drawn from assessments of co-facilitated training events; a collective review of field notes; and informal discussions among co-authors and with LRCs and Network Investigators. We draw on our individual and collective experiences. Specific examples outlining the evolution of foundational questions, partner and stakeholder research priorities, and preliminary results will be shared. We offer our reflections in order to support future efforts in this emerging capacity-enhancement-and-partnership approach to research, and to contribute to ongoing discussions surrounding capacity enhancement, partnership research, and Inuit self-determination thus building societal resilience to changing weather, climate, oceans and environment.

Session: 2010351 Interdisciplinary and climate research on resilience - Part 2 Recherche interdisciplinaire et climatique sur la résilience - Partie 2

04/06/2020 13:00

ID: 10589 Contributed abstract

Going to extremes: from risk to resilience

Roger Pulwarty [1]

[1] NOAA

Presented by / Présenté par: ***Roger Pulwarty***
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There is increasing awareness among governments, businesses and the general public of risks arising from a varying and changing climate. Several rounds of international assessments including IPCC Reports, UNDRR and national assessments have renewed the urgency to reduce the associated risks. The cascading nature of climate events across global, regional, national and local scales is a fundamental characteristic of emerging risks. At the same time, the modern world is significantly more connected and technologically advanced than when the first IPCC assessment was conducted. As essential as the urgency for assessing the causes and impacts of climate extremes and trends, is the critical need to avoid a false image of risks being faced (e.g. spurious certitude on local manifestations of change) and the attendant underestimation of the complexities of adaptation. The challenges illustrate the need not only to understand and design information services and systems “for” change but to design robust knowledge and practice systems that help us navigate “through” changes and associated proximate and systemic risks. As critical, is the need for use-inspired research that bridges basic and applied frames. More than useful or even usable information is needed, what is required are pathways to improved decisions that thread through disaster risk reduction, adaptation, sustainability i.e. from risk to resilience. Drawing on the author’s research and experience, this talk outlines, (1) the changing nature of interconnected risks across the globe, (2) options, challenges and opportunities for implementing adaptation strategies in different sectors and countries, (3) regional and local climate information systems that share research, decision support tools and smart practices, and (4) the coordination and capacity needed for securing the co-benefits of weather and climate risk management across economies, ecosystems and communities. Added to this, are the needs to align the science-policy

interface cross global agendas including the Sendai Framework, adaptation under the UNFCCC, Sustainable Development Goals, and the Convention on Biological Diversity.

Session: 2010351 Interdisciplinary and climate research on resilience - Part 2 Recherche interdisciplinaire et climatique sur la résilience - Partie 2

04/06/2020 13:25

ID: 10591 Contributed abstract

Using science to build resilient communities

Paul Kovacs [1]

[1] Institute for Catastrophic Loss Reduction

Presented by / Présenté par: ***Paul Kovacs***
Contact: pkovacs@iclr.org

Damage to Canadian buildings and public infrastructure has been doubling every 5 to 10 years since the 1980s. Science provides a foundation for action to build community resilience and confront this alarming trend. The application of climate and loss models, behaviour research and other emerging knowledge holds great potential to enhance resilience to extreme weather and climate-related hazards. In particular, the Sendai Framework for Disaster Risk Reduction sets out a comprehensive approach to build community resilience.

Session: 2010351 Interdisciplinary and climate research on resilience - Part 2 Recherche interdisciplinaire et climatique sur la résilience - Partie 2

04/06/2020 13:45

ID: 10325 Contributed abstract

Canadian National Climate Archive - Ensuring Reliable Records

Anna Deptuch-Stapf [1] , *Christopher Kocot* [2] , *Brian Wannamaker* [3]

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[2] Climate Historical Archives Downsview, Monitoring and Data Services Directorate, ECCC
[3] Sea Scan International

Presented by / Présenté par: ***Anna Deptuch-Stapf***
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Climate modellers need reliable meteorological data stretching back over decades to develop and test the reliability of future predictions. Engineers depend upon historical records to design civil infrastructure to withstand the weather where it will be built. The

general public needs have access to reliable historical data to be convinced that the climate is actually changing.

Core meteorological data stored within the Canadian National Climate Archive comes from millions of hardcopy forms, collected and archived since 1840. Historically, the data on these forms have been recorded by trained weather observers at thousands of locations across the country. As part of preserving this heritage, close to a million of the original forms are currently being digitally scanned and delivered to the Meteorological Service of Canada (MSC) in large batches of about 20,000 images at a time. Until now, reviewing this volume of scans was impossible, as it had to be completed manually.

Through the support of the Environment Canada and Climate Change Future Fund, MSC Archive Operations are leveraging a commercial digital media manipulation toolkit to implement an innovative Visual Interactive Quality Assurance (VIQA) process. This will allow us to quickly review each scanned form and ensure that poor quality or faulty scans will not enter into the Climate Archives. Consequently, this will increase the integrity and value of this portion of the Archive and provide confidence that its scans reliably represent the original paper collection.

We expect that continuing experimentation and expansion of this innovative approach will work toward improving access to all of the digital collections and to making Environment and Climate Change Canada's 180-year legacy of original weather and climate data records accessible to a wider audience.

Session: 2010351 Interdisciplinary and climate research on resilience - Part 2 Recherche interdisciplinaire et climatique sur la résilience - Partie 2

04/06/2020 14:00

ID: 10530 Contributed abstract

Communicating Winter Storms via Natural Language Processing of Social Media

Renee Sieber [1], *Andrei Romascanu* [2], *Sam Lumley* [3], *Mikael Brunila* [4], *Rosie Zhao* [5]

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[5]

Presented by / Présenté par: ***Renee Sieber***
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Social media can be invaluable for understanding how the public and officials communicate extreme weather events. However, social media big data presents a huge

signal to noise problem, which challenges the derivation of actionable information. Natural language processing, a branch of artificial intelligence, can help automate knowledge extraction and therefore allow us to capitalize on big social media data to better respond to these types of events. We compare and contrast two ML techniques. We harvested data from social media, specifically approximately 300,000 tweets, during three recent extreme winter weather events in Canada and perform unsupervised classification (topic modelling) and supervised classification (recurrent neural network) to better understand and visualize what the general public is saying about winter storms in real-time as they unfold.

In addition to reporting on the results, we compare the pros and cons of each technique. We find that supervised classification can be performed in real time and is easier for non-data scientists to interpret. However, it requires a model that has been pre-trained on tens of thousands of known social media posts, a prescriptive constraint that limits the available labels. We trained ours on the most widely-used training dataset, CrisisNLP, and discuss its appropriateness for Canadian weather. Unsupervised classification cannot easily be accomplished in real time because it relies on a very large corpus (e.g., 1 million words) of already collected material. It also is difficult to interpret and requires considerable domain knowledge to increase its comprehension. Finally, we place this presentation in the context of a larger Environment and Climate Change Canada-funded project to leverage social media to understand and dynamically visualize how the public reacts to extreme weather.

Session: 2010351 Interdisciplinary and climate research on resilience - Part 2 Recherche interdisciplinaire et climatique sur la résilience - Partie 2

04/06/2020 14:15

ID: 10381 Contributed abstract

Collision-Induced Absorption of CH4-CO2 and H2-CO2 Complexes and Their Effect on the Ancient Martian Atmosphere

Paul Godin [1] , *Ramses Ramirez* [2] , *Charissa Campbell* [3] , *Tyler Wizenberg* [4] , *Tue Giang Nguyen* [5] , *Kimberly Strong* [6] , *John Moores* [7]

[1] York University
[2] Tokyo Institute of Technology
[3] York University
[4] University of Toronto
[5] York University
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[7] York University

Presented by / Présenté par: ***Paul Godin***
Contact: pgodin@yorku.ca

Experimental measurements of collision-induced absorption (CIA) cross-sections for CO2-H2 and CO2-CH4 complexes were performed using Fourier transform spectroscopy over a spectral range of 100-500 cm^-1 and a temperature range of 200-300 K. These experimentally derived CIA cross-sections agree with the spectral range and temperature dependence of the calculation by Wordsworth et al. (2017) however the amplitude is half of what was predicted. Furthermore, the CIA cross-sections reported here agree with those measured by Turbet et al. (2019). The CIA cross-sections can be applied to planetary systems with CO2 -rich atmospheres, such as Mars and Venus, and will be useful to terrestrial spectroscopists.
Additionally, radiative transfer calculations of the early Mars atmosphere were performed and showed that CO2-CH4 CIA would require surface pressure greater than 3 bar for a 10% methane atmosphere to achieve a temperature of 273 K at the surface. CO2-H2, however, liquid water is possible with 5% hydrogen and less than 2 bar of surface pressure.

Day 9 - 8 June 2020

Convener: Melissa MacDonald, ECCC

This is a session inviting presentations on the topics of risks and impacts on the health and environment of Canadians in a changing Climate using prediction elements such as modelling and forecasting, new health and monitoring research as well as case studies associated with the provision of health services. A changing climate is the contributing factor to extreme temperature events (heat and cold), to air quality events caused by wildfire smoke, to longer seasons for aeroallergens, and to new vector-borne diseases. Papers related to innovative applications for communicating health risks, how to improve services for Canadians to build resiliency, as well as social and mental health impacts are also encouraged to submit.

Session: 2010150 Building resiliency in Health and Environment in a changing Climate Renforcer la résilience relativement à la santé et à l'environnement face aux changements climatiques — 08/06/2020 11:00

ID: 10492 Contributed abstract

Priority setting to improve the Ecological Footprint and biocapacity accounting

[1]

[1]

Presented by / Présenté par: ***Mary Thornbush***
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After being introduced by Rees and Wackernagel in the early 1990s, the Ecological Footprint

has received attention as part of an ongoing debate that has targeted conceptual and methodological criticisms. The Footprint Data Foundation (FoDaFo) has recently established the Scientific Advisory Committee (SAC) led by Professor Peter Victor to address these problems and concerns. This presentation conveys the process executed by SAC to improve the Ecological Footprint and biocapacity accounting both conceptually and methodologically. More specifically, a literature review is being compiled that will encompass all known un/published critical papers, including those that present new methods. Based on this literature review, 10 thematic areas of criticisms emerged that provided SAC the basis for setting proprieties to set the research agenda for improving the top three targets selected in a recent SAC meeting. These priorities are deployed in moving forward as a way to focus the research agenda and involve experts.

Session: 2010150 Building resiliency in Health and Environment in a changing Climate Renforcer la résilience relativement à la santé et à l'environnement face aux changements climatiques

08/06/2020 11:15

ID: 10282 Contributed abstract

A Canadian Lidar Network for Measurements of Clouds, Aerosols, Forest Fire Smoke, and Volcanic Ash

Robert Sica [1] , *J. P. Blanchet* [2] , *Rachel Chang* [3] , *James Drummond* [4] , *Alexander Haefele* [5] , *Patrick Hayes* [6] , *Emily McCullough* [7] , *Norm O'Neill* [8] , *Kim Strong* [9] , *Aldona Wiacek* [10] , *Douglas Woolford* [11] , *Debra Wunch* [12]

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[2] Universite du Quebec a Montréal
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Presented by / Présenté par: ***Robert Sica***
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We are assembling a network of automated lidars with the capability to measure aerosol type and discriminate liquid water versus ice layers using polarization of the lidar return signal. These lidars will be installed at key nodes in the Canadian Anchor Sites for SAtellite Validation (CASSAVA) network including 2 sites which are small urban islands in

rural settings (London; Sherbrooke), an urban environment (Toronto), a marine environment (Halifax), and at the Canadian Network for the Detection of Atmospheric Change (CANDAC) Polar Environment Atmospheric Research Laboratory (PEARL) at Eureka, Nunavut in the high Arctic. Transport of particulates, sometimes across great distances, can pose health and safety risks. Networks of small automated lidar can provide the measurements required by particulate transport models to track wildfire smoke or volcanic ash in near real-time, like weather radars can currently track storms. The benefits of particulate tracking include monitoring air quality, determining safe corridors for air travel during fire and volcanic events, and to help in managing wildfires, in particular in determining when and if to evacuate remote areas.

The ability of these lidars to distinguish particle type will also allow us to improve models of cloud and fog formation by measuring whether the water in clouds is liquid, ice, or mixed.The lidar network will also be used to quantify the impact of atmospheric particulates on the interpretation of ozone trends measured by surface-based, total-column instruments and to better understanding the link between surface pollution measurements (such as PM2.5), columnar measurements (AEROCAN/AERONET) and satellite (columnar) retrievals. We expect the network to be fully operational within the next year, and the lidar measurements will be made available to the scientific community.

Session: 2010150 Building resiliency in Health and Environment in a changing Climate Renforcer la résilience relativement à la santé et à l'environnement face aux changements climatiques 08/06/2020 11:30

ID: 10566 Contributed abstract

Wildfire Smoke Readiness in Canada using the Air Quality Health Index (AQHI)

Celine Audette [1]

[1] ECCC-MSC

Presented by / Présenté par: ***Celine Audette***
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Using the Air Quality Health Index program, Canada has implemented a PM2.5 based AQHI to improve the alerting system and health messages for Canadians during Wildfire Smoke events. Wildfire smoke contains toxic air pollutants, including fine particles that can penetrate deep into our lungs and sometimes lead to serious health effects. Those at greater risk of these effects are young children, pregnant women, the elderly, people with respiratory and cardiovascular conditions and people involved in strenuous outdoor work or sports.
The Air Quality Health Index developed and in use since 2005, is based on a 3hr weighted average of three pollutants, NO2, O3 and PM2.5. This formula reports an index number that informs the public of pollution levels and how to minimize their risk to health. During wildfire events, the 3 pollutant AQHI is unresponsive to changing

conditions. Based on the respiratory research from the BC-Center for Disease Control and the BC Environment PM2.5 pilot program from May 2018 to October 2019, ECCC is implementing nationally an AQHI using PM2.5 for wildfire smoke events (will refer to this method as AQHI+). The revised formula is PM2.5 concentration in micrograms per meter cubed divided by 10, the ceiling value is used to calculate the new AQHI+ value. AQHI+ = (ceiling [PM2.5]/10)

To increase its coverage of measurements, a small sensor project implementation is underway for the 2020 season to measure PM2.5 in remote, under serviced and Indigenous territories. Small sensors track the measurements of Federal Equivalent Method (FEM), however, it is a known issue that they overestimate the PM2.5 values by 50-60%. By collocating the sensors with stationary monitoring, ECCC will develop correction factors for the PM2.5. This network of sensors will offer real time observation of PM2.5 for remote communities to detect smoke. This work will also support prediction-related goals and regional service and prediction operations.

The new AQHI formula for wildfire smoke using PM2.5 and subsequent health messaging will better inform the public on how they can self-calibrate to protect their health and minimize their risk during these adverse events.

Session: 2010150 Building resiliency in Health and Environment in a changing Climate Renforcer la résilience relativement à la santé et à l'environnement face aux changements climatiques

08/06/2020 11:45

ID: 10593 Contributed abstract

Health Impact Analysis of Wildfire Smoke in Canada

Carlyn Matz [1] , *Marika Egyed* [2] , *Guoliang Xi* [3] , *Jacinthe Racine* [4] , *Radenko Pavlovic* [5] , *Robyn Rittmaster* [6] , *Sarah Henderson* [7] , *Dave Stieb* [8]

[1] Health Canada
[2] Health Canada
[3] Health Canada
[4] Environment and Climate Change Canada
[5] Environment and Climate Change Canada
[6] Health Canada
[7] BC CDC
[8] Health Canada

Presented by / Présenté par: ***Carlyn Matz***
Contact: carlyn.matz@canada.ca

Smoke from wildfires contains many air pollutants of concern including particulate matter (PM), carbon monoxide (CO), nitrogen oxides (NOX), methane (CH4), polycyclic aromatic hydrocarbons (PAHs), and volatile organic compounds (VOCs), and contributes to formation of ozone (O3) and secondary PM. Epidemiological

studies have identified associations between exposure to wildfire smoke PM2.5 and mortality and respiratory morbidity, and a possible association with cardiovascular morbidity. For this study, air quality modelling was performed using a retrospective analysis of Environment and Climate Change Canada's FireWork PM2.5 forecasts, to quantify the exposure to wildfire -PM2.5 across the Canadian population. The model included wildfire emissions from across North America for a 5-month period from May to September (i.e. wildfire season), between 2013 and 2018. Large variations in wildfire -PM2.5 were noted year -to-year, geospatially, and within fire season. The model results were then used to estimate the national population health impacts attributable to wildfire-PM2.5 using Health Canada's Air Quality Benefits Assessment Tool (AQBAT). The analysis estimated annual premature mortalities ranging from 54 -240 premature mortalities attributable to short-term exposure and 570-2500 premature mortalities attributable to long-term exposure, as well as many non-fatal cardiorespiratory health outcomes. Combined these health impacts have an estimated value of $4.6B to $20B per year. The health impacts were greatest in the provinces with populations in close proximity to wildfire activity, though health impacts were also noted across many provinces indicating the long-range transport of wildfire-PM2.5. Understanding the population health impacts of wildfire smoke is important as climate change is anticipated to increase wildfire activity in Canada and abroad.

Session: 2010150 Building resiliency in Health and Environment in a changing Climate Renforcer la résilience relativement à la santé et à l'environnement face aux changements climatiques

08/06/2020 12:00

ID: 10567 Contributed abstract

Extreme Temperatures in Canada: A review of recent impact-based heat warning changes and the analysis of possible changes to the Extreme Cold Warnings Criteria for Canada

Cara Patton [1]

[1] ECCC

Presented by / Présenté par: ***Cara Patton***
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Climate change and variability are affecting the health and well-being of people around the globe and these risks are increasing. In Canada, the health of Canadians is being impacted by climate change through extreme heat and cold events among others. The World Health Organization (WHO) and World Meteorological Organization (WMO) issued joint guidance in 2015 on heat warning system development to reduce heat health risk, warning that these events will increase in the future due to climate change. With the WHO and WMO guidance and available health analysis, Environment Climate Change Canada

(ECCC) has modernized their Heat Warning criteria to reflect a standardized service with regional character. ECCC is also investigating potential changes to the Extreme Cold warning criteria in Canada. In some regions of Canada, the current extreme cold warning criteria thresholds are rarely met and are not representative of the regional climatology. This presentation will detail the work in both sides of extreme temperature. For Heat, how historical climate data and (Geographical Information System) GIS mapping have been used to develop heat warning regions, supported by health expertise, to develop evidence-based heat warnings across Canada. For Cold, the presentation will feature some of the analysis to inform the decisions on changing the extreme cold warning criteria for some regions of Canada.

Session: 2010150 Building resiliency in Health and Environment in a changing Climate Renforcer la résilience relativement à la santé et à l'environnement face aux changements climatiques

08/06/2020 12:15

ID: 10595 Contributed abstract

Environmental factors and airborne pollen; a multidisciplinary perspective.

Alain Robichaud [1]

[1] Environment and Climate Change Canada

Presented by / Présenté par: ***Alain Robichaud***
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Bioaerosols (bacteria, fungal spores, pollen, fragments, vegetative detritus, etc.) are ubiquitous. It has been argued that they can play a significant role in atmospheric science: biodegradation in clouds, play a role as ice and condensation nuclei, impacts radiative budget and climate change. Moreover, their impact on health could be severe at times (pollen and spore allergy, contamination by bacteria, asthma exacerbation, etc.). Therefore, more modelling and monitoring of bioaerosols are needed. In this presentation, the focus is on birch pollen modelling and the potential synergy with environmental factors (meteorology, air pollution).

Session: 2010150 Building resiliency in Health and Environment in a changing Climate Renforcer la résilience relativement à la santé et à l'environnement face aux changements climatiques

08/06/2020 12:30

ASSESSING SUB-DAILY EXPOSURE TO WILDFIRE SMOKE AND ITS PUBLIC HEALTH EFFECTS IN BRITISH COLUMBIA

Angela Yao [1] , *Michael Brauer* [2] , *Sarah Henderson* [3]

[1] BC Centre for Disease Control
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[3] BC Centre for Disease Control

Presented by / Présenté par: ***Angela Yao***
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Background: Exposure to fine particulate matter (PM2.5) during wildfire seasons has been associated with adverse health outcomes. Previous studies have focused on daily exposure, but PM2.5 levels in smoke events can vary considerably within one day.
Objectives: To assess the immediate and lagged relationship between sub-daily exposure to PM2.5 and acute health outcomes during wildfire seasons in British Columbia.
Methods: We used a time-stratified case-crossover study design to evaluate the association between modeled hourly PM2.5 and ambulance dispatches during wildfire seasons from 2010 to 2015. Distributed lag non-linear models were used to estimate the lag-specific and cumulative odds ratios at lags from 1 to 48 hours. We examined the relationship for all dispatches, and dispatches related to respiratory, circulatory and diabetic conditions, identified by codes for ambulance dispatch (AD), paramedic assessment (PA) or hospital diagnosis (HD).
Results: Increased respiratory health outcomes were observed within 1 hour of exposure to a 10 µg/m3 increase in PM2.5. The 48-hour cumulative odds ratio (OR) [95% CI] was 1.038 [1.009, 1.067] for the AD code Breathing Problems and 1.098 [1.013, 1.189] for PA code Asthma/COPD. The point estimates were elevated within 1-hour for the PA code for Myocardial Infarction and HD codes for Ischemic Heart Disease, which had 24-hour cumulative ORs of 1.104 [0.915, 1.331] and 1.069 [0.983, 1.162], respectively. The odds of Diabetic AD and PA codes increased over time to a cumulative 24-hour OR of 1.075 [1.001, 1.153] and 1.104 [1.015, 1.202] respectively.
Conclusions: We found increased PM2.5 during wildfire seasons was associated with some respiratory and cardiovascular outcomes within 1-hour following exposure, and its association with diabetic outcomes increased over time. Cumulative effects were consistent with those reported elsewhere in the literature. These results warrant further investigation and may have implications for the appropriate time scale of public health actions.

Recent observational and modelling studies show that the warming ocean has had, and will continue to have, a significant impact on the concentration, thickness and seasonality of sea ice. According to the National Snow and Ice Data Center (NSIDC), the past ten years hold the record minimum sea ice extents out of all years on record. As the ocean has a much lower albedo than sea ice, retreating sea ice increases solar radiation absorbed by the ocean; this increases the temperature of the ocean, which further decreases sea ice coverage. The Arctic Ocean is particularly vulnerable to this positive feedback mechanism and experiences amplified change. These responses under a changing climate have significantenvironmental and social impacts on communities and animals in high-latitude regions. For Indigenous communities who rely on sea ice for traveling, hunting, food and other resources, the changing sea ice-ocean dynamic poses a great threat to their daily lives. For animals such as polar bears who need sea ice for resting, hunting and traveling, their survival is threatened with declined sea ice. Reduced sea ice coverage also allows for increased maritime activities including shipping and fishing, which increase the risk of oil spills and disrupt the ecosystem. Hence, there is an urgent need to better identify the ocean-sea ice interaction under a changing climate and the impacts on the environment and communities in the high latitudes. This research could improve future projections and consequently help communities, rights-holders and policy-makers plan for mitigation strategies to build resilience against these changing conditions.

We invite contributions from researchers, Indigenous communities, policy-makers, NGOs and others investigating how the oceans and sea ice are changing, those reporting on the societal impacts of changing oceans and sea ice conditions, and those working on mitigating threats due to changing sea ice and ocean conditions.

Session: 2010190 Ocean-sea ice interaction in a changing climate: Environmental and societal impacts - Part 1 Les interactions entre la glace de mer et l'océan dans un climat en évolution : impacts environnementaux et sociétaux - Partie 1 08/06/2020 11:00

ID: 10289 Contributed abstract

Changing Ice Conditions in the Canadian Arctic: The Canadian Ice Service Perspective

Doug Leonard [1]

[1] Canadian Ice Service

Presented by / Présenté par: ***Doug Leonard***
Contact: scott.weese@canada.ca

The Canadian Ice Service (CIS), a division of the Meteorological Service of Canada in Environment and Climate Change Canada (ECCC), is the leading authority for ice and iceberg information in Canada's navigable waters. This information helps to ensure the safety of Canadians, their property and their environment, by warning them about dangerous ice conditions, as well as shaping the development of sound environmental policies. This talk will highlight some of the opportunities, issues and challenges that are present in an ice-diminishing Canadian Arctic from the perspective of an operational ice centre. Trends in Arctic sea ice will be discussed, with particular emphasis on how they influence present and future service delivery at the CIS. The role of an evolving ice service will be examined in the context of a new climate regime.

Session: 2010190 Ocean-sea ice interaction in a changing climate: Environmental and societal impacts - Part 1 Les interactions entre la glace de mer et l'océan dans un climat en évolution : impacts environnementaux et sociétaux - Partie 1 08/06/2020 11:15

ID: 10227 Contributed abstract

Increased Arctic Ocean sea ice loss through the Canadian Arctic Archipelago under a warmer climate

Stephen Howell [1] , *Mike Brady* [2]

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Presented by / Présenté par: ***Stephen Howell***
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The ice arches that ring the northern Canadian Arctic Archipelago have historically blocked the inflow of Arctic Ocean sea ice for the majority of the year. However, annual average air temperature in northern Canada has increased by more than 2 degrees Celsius over the past 65+ years and a warmer climate is expected to contribute to the deterioration of these ice arches, which in turn has implications for the overall loss of Arctic Ocean sea ice. We investigated the effect of warming on the Arctic Ocean ice area flux into the Canadian Arctic Archipelago using a 22-year record (1997-2018) of ice exchange derived from RADARSAT-1 and RADARSAT-2 imagery. Results indicated that there has been a significant increase in the amount of Arctic Ocean sea ice (10^3 km^2/year) entering the northern Canadian Arctic Archipelago over the period of 1997-2018. The increased Arctic Ocean ice area flux was associated with reduced ice arch duration but also with faster (thinner) moving ice and more southern latitude open water leeway as a result of the Canadian Arctic Archipelago's long-term transition to a younger and thinner ice regime. Remarkably, in 2016, the Arctic Ocean ice area flux into the Canadian Arctic Archipelago (161x10^3 km^2) was 7 times greater than the 1997-2018 average (23x10^3 km^2) and almost double the 2007 ice area flux into Nares Strait (87x10^3 km^2). Indeed, Nares Strait is known to be an important pathway for Arctic Ocean ice loss however, the results of this study suggest that with continued warming, the Canadian Arctic Archipelago may also become a large contributor to Arctic Ocean ice loss. Moreover, this study also provides yet more evidence that a warmer Arctic facilitates more Arctic Ocean ice transport to southern latitudes which is problematic for the maritime industry.

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ID: 10451 Invited session speaker

High Resolution NEMO Modelling for northern Canadian Waters

Paul Myers [1] , *Xianmin Hu* [2] , *Laura Castro de la Guardia* [3] , *Laura Gillard* [4] , *Nathan Grivault* [5] , *Andrew Hamilton* [6] , *Juliana Marson* [7] , *Clark Pennelly* [8] , *Ran Tao* [9]

[1] University of Alberta
[2] Bedford Institute of Oceanography
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Presented by / Présenté par: ***Paul Myers***
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The numerical modelling framework of the Nucleus for the European Modelling of the Ocean (NEMO) is now widely used throughout Canada. Here we use the Arctic and Northern Hemisphere Atlantic (ANHA) regional configuration developed at the University of Alberta to present an overview of modelling capabilities and results for northern Canadian Waters. As well as base ¼ and 1/12 degree resolution configurations, we considered the application of 1/12 and 1/60 degree nests for the Canadian Arctic, using the AGRIF grid refinement package. The use of the TOP package for passive tracers, integration of a Lagrangian iceberg module and coupling to the biogeochemical model BLING will be discussed. The role of the inclusion of explicit tidal mixing will be examined. A specific application of using model output and the Lagrangian float tool Ariane to examine regions of sensitivity to potential pollutant spills along regional shipping routes will also be presented. Additional discussion will focus on mixed layer depths. Given the general scarcity of oceanographic observations in the Canadian Arctic, model simulations have the potential to provide critical insight into ocean processes and guide the development of observational and management initiatives.

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ID: 10348 Contributed abstract

Impact of horizontal spatial resolution on ocean heat transport and Arctic sea ice extent in a climate model suite

Marine Decuypere [1] , *Carolina Dufour* [2] , *Bruno Tremblay* [3]

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Presented by / Présenté par: ***Marine Decuypere***
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Climate model projections of Arctic sea ice extent (SIE) underestimate the observed rate of decline in the minimum sea ice extent. A recent study links future rapid SIE declines with ocean heat transport (OHT) anomalies through the Barents Sea Opening and the Bering Strait, when the sea ice extent is large enough to cover the continental shelves (Auclair et al., 2018). Moreover, several studies show that high resolution ocean models tend to produce higher Atlantic ocean heat transport into the Barents Sea Opening than their coarser resolution counterparts (e.g. Docquier et al., 2019). Since ocean currents are tightly constrained by topography, we expect ocean models of different resolutions to show different patterns and intensity in sea ice melting. Here, we use a hierarchy of global climate models that only differ from one another by the horizontal spatial resolution in the ocean (0.1°, 0.25°, and 1°) to investigate the impact of horizontal resolution on ocean heat transport and subsequent sea ice melting in the Arctic. We use pre-industrial simulations to evaluate the seasonal cycle in SIE against in-situ observations from the Sea Ice Back to 1850 data set (SIBT1850, Walsh et al., 2015). We then compare the response of the Arctic SIE to climate change across the model suite using simulations where CO2 is increased at a rate of 1%/year. In particular, we quantify the changes in seasonality and in total OHT of Atlantic and Pacific origin in the Arctic Ocean.

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08/06/2020 12:00

ID: 10264 Contributed abstract

Impact of seasonal ice coverage on the general circulation in the Kitikmeot Sea of the Canadian Arctic

Chengzhu Xu [1] , *Paul G. Myers* [2] , *Qi Zhou* [3]

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Presented by / Présenté par: ***Chengzhu Xu***
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Located in the southern Canadian Arctic Archipelago, the Kitikmeot Sea is an east-west waterway of approximately 500 km long. It consists of Coronation Gulf and Queen Maud Gulf, connected by Dease Strait near Cambridge Bay, Nunavut. Ocean circulation in the Kitikmeot Sea is unique due to the seasonal ice coverage and the narrow straits and shallow sills at both ends that bound the semi-enclosed water body. In the present work, wind-driven

circulation and density stratification in the Kitikmeot Sea are diagnosed using the Nucleus for European Modelling of the Ocean (NEMO) numerical framework at a resolution of 1/12 degree. By examining the temperature, salinity, ocean current and sea-ice coverage over the past decade, it is found that while time-averaged flow over multiple years is generally eastward and is similar to the rest of the Canadian Archipelago, the physical oceanography in the Kitikmeot Sea exhibits strong seasonal variations, primarily due to seasonal ice coverage and massive freshwater input from river inflow. During ice-free season (July to October), freshwater input enhances the density stratification, while wind stress reverses the flow direction in the surface layer from eastward to westward. Below the pycnocline, however, the flow of dense water remains eastward, inducing strong velocity shear across the pycnocline and potential for diapycnal mixing. By studying the impact of seasonal ice coverage on the stratification and circulation of the Kitikmeot Sea, we hope to determine if there exists a predominant mechanism for material mixing in this region and, if so, its implication on the biogeochemistry, the ecosystem, and the local indigenous communities.

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08/06/2020 12:15

ID: 10255 Contributed abstract

On the role of the Antarctic Slope Front on the occurrence of the Weddell Sea polynya under climate change

Joseph Lockwood [1] , *Carolina Dufour* [2] , *Stephen Griffies* [3] , *Michael Winton* [4]

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[3] NOAA/GFDL and Princeton University
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Presented by / Présenté par: ***Carolina Dufour***
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Polynyas are large holes in sea ice that have a significant impact on the climate through feedback with the atmosphere and modification of the global ocean circulation. In this study, we investigate the occurrence of the Weddell Sea Polynya (WSP) under an idealized climate change scenario by evaluating simulations from climate models of different ocean resolutions. The GFDL-CM2.6 climate model, with roughly 3.8 km horizontal ocean grid spacing in the high latitudes, forms a WSP at similar time and duration under idealized climate change forcing as under pre-industrial forcing. In contrast, all convective models forming the fifth phase of the Coupled Model Intercomparison Project (CMIP5) show either a cessation or a slowdown of WSP events under climate warming. The representation of the Antarctic Slope Current and related Antarctic Slope Front is found to be key in explaining the differences between the two

categories of models, with these features being of realistic strength in CM2.6, yet weak and/or missing in CMIP5 models. In CM2.6, the freshwater input driven by sea ice melt and enhanced runoff found under climate warming largely remains on the shelf region since the slope front restricts the lateral spread of the freshwater. In contrast, for most CMIP5 models, open ocean stratification is enhanced by the freshening since the absence of a slope front allows coastal freshening to spread into the open ocean, thus resulting in a slow down in the occurrence of WSPs. Hence, poor representation of Weddell Sea shelf processes in CMIP5 models might affect the ability of these models to predict the fate of the WSPs under climate change, and more generally, to accurately predict the response of stratification to climate change at high latitudes.

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08/06/2020 13:00

ID: 10257 Invited session speaker

The increasing need for operational ice services in the opening Arctic

Keld Qvistgaard [1]

[1]

Presented by / Présenté par: ***Keld Qvistgaard***
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The ice-covered Polar Waters are changing rapidly. Longer operational windows give new opportunities for shipping and other activities at sea, but new risks and challenges are also imposed for mariners, especially those with little experience in navigating the Arctic Waters safely.

The ice services around the Globe have over the past decades experienced not just more ships and longer seasons, but also increasing mariner diversity and ice product requirements, ranging from non-ice class cruise ships with 1000+ passengers needing to avoid all ice to Polar Class icebreakers navigating multi-year sea ice in the Arctic Ocean.

The recent decline in ice leads to more activity for the operational ice services serving shipping daily. The ice services collaborate closely in the International Ice Charting Working Group to address cross-border challenges, coordinate joint efforts and take full advantage of science and technology advances to serve the marine community for safe decision-making in ice-covered waters.

The presentation will provide an overview of the recent ice service advances and future trends in serving the marine community navigating the Arctic.

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08/06/2020 13:15

ID: 10246 Contributed abstract

Assessing potential iceberg risk along shipping routes in the Eastern Canadian Arctic

Abigail Dalton [1] , *Alison Cook* [2] , *Luke Copland* [3] , *Wesley Van Wychen* [4]

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Presented by / Présenté par: ***Abigail Dalton***
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Tidewater glaciers drain a significant proportion of the Greenland Ice Sheet and the ice caps of the Canadian Arctic, and provide the primary source of icebergs and ice islands in Canadian waters. Increased navigability of Arctic waters, resulting from climate change, has played a role in the rapid recent increase in shipping traffic in Arctic Canada. However, we currently know little about the primary drift paths of icebergs in the Canadian Arctic, whether they are changing over time, and the potential risks they may pose to ships as vessel traffic increases.

Using the CCGS Amundsen icebreaker from 2016-2019, ~50 icebergs in Baffin Bay were visited to install helicopter-deployed satellite tracking beacons to monitor their near real-time movement. Initial results show that their motion is dominated by drift to the south along the western side of Baffin Bay, primarily driven by ocean currents, with bathymetry influencing the exact iceberg drift location. Results from the last ~3 years show that the most active iceberg moved at a rate of about 26.6 km/day, with the greatest distance travelled by an iceberg of >5600km over a 390 day period. A comprehensive database of ship tracks derived from NORDREG (Northern Canada Vessel Traffic Services Zone Regulations) data has shown increasing trends in shipping activity throughout Baffin Bay between 1990 and 2018, including more non-ice strengthened vessels and fewer ice-strengthened vessels. This study will use known ship tracks and iceberg locations to create risk maps focusing on communities that are close to regions of high iceberg and shipping traffic such as Pond Inlet, Clyde River, and Qikiqtarjuaq.

ID: 10542 Contributed abstract

Aerial observations of sea ice breakup by ship-generated waves

Élie Dumas-Lefebvre [1] , *Dany Dumont* [2]

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Presented by / Présenté par: ***Élie Dumas-Lefebvre***
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The marginal ice zone is the name given to the area of sea ice being influenced by ocean waves.Therein, numerous feedbacks having a direct influence on climate and sea ice dynamics arise from complex physical processes that are only partially understood and poorly quantified. Of these processes, one of the most visually astonishing is the wave-induced sea ice breakup. By modifying the floe size distribution, it significantly impacts sea ice dynamics which in turn influences atmosphere-ocean fluxes thus triggering feedbacks. The occurrence of natural sea ice breakup being very difficult to predict, and thus to observe in detail, we used a ship to generate waves in the vicinity of large ice floes as a way to observe and study the breakup process. Here we present the results of two experiments carried out in the Gulf of St.-Lawrence during winter 2019 and in northern Baffin Bay during summer 2019 on board CCGS Amundsen. High resolution footage obtained using a downward -looking drone allowed the extraction of detailed information about the evolution of floe size during breakup events. The main results obtained are that (i) the floe size distribution exhibits either a unimodal or bimodal shape, (ii) the position of the mode seems independent of the incoming wavelength but rather dependent on thickness and flexural rigidity of sea ice, (iii) the breakup speed is a considerable fraction of wave speed, and (iv) the temperature of sea ice seems to be an important factor influencing breakup extent. These results are consistent with those obtained from thin elastic plate models in term of fracture distance form the edge (floe size), rather than a criterion solely based on wavelength, and provide very useful insights for the development and refinement of break-up parameterizations.

ID: 10376 Contributed abstract

Short-Term Modelling of Mechanical Sea Ice Break-Up Processes in Admiralty Inlet, NU

Ada Loewen [1] , *Gregory Crocker* [2] , *Derek Mueller* [3] , *Richard McKenna* [4] , *Calder Patterson* [5]

[1] Carleton University
[2] Carleton University
[3] Carleton University
[4] R.F. McKenna Associates
[5] Carleton University

Presented by / Présenté par: ***Ada Loewen***
Contact: ada.loewen@carleton.ca

Oceanic conditions can be highly variable during the break-up season, posing a risk for ship navigation and on-ice transportation. Recent changes in the Arctic climate have resulted in changes in sea ice break-up patterns, reducing the applicability of traditional knowledge and making assessment of safe travel on sea ice increasingly difficult. Currently, there are few resources available for short-term predictions (days to hours) of ice and ocean conditions that are of use to Northern communities to evaluate ice conditions.

Admiralty Inlet is located on the northern shore of Baffin Island and extends south from Lancaster Sound. It is an important environment for the people from the community of Arctic Bay. Sea ice in Admiralty Inlet is seasonally landfast but during the break-up season, large ice floes may break off from the landfast ice and drift away. This has resulted in incidents where people have become stranded on drifting ice floes. This research uses a combination of oceanographic and meteorological field observations from Admiralty Inlet, NU and finite element modelling to study the dynamic processes causing sea ice break-up events in this region.

Preliminary results have suggested that attachment points of sea ice at the shoreline may produce important forces counteracting the action of wind and current stresses, preventing break-out events until the shoreline attachment deteriorates. Modelling studies will quantify these forces to increase our understanding of the dynamic mechanisms of sea ice break-up and enhance our capacity to predict future break-out events.

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impacts environnementaux et sociétaux - Partie 2 14:00

ID: 10527 Contributed abstract

Community Concerns around Sea Ice

Thomas Zagon [1] , *Angela Cheng* [2]

[1] Canadian Ice Service
[2] Canadian Ice Service

Presented by / Présenté par: ***Thomas Zagon***
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Sea ice is an integral transportation platform for Inuit hunting and fishing to maintain their nutritional and cultural needs. Recent community consultations in northern communities by Canadian Ice Service (CIS) staff have identified a desire for sea ice products to augment local knowledge and to prevent Search and Rescue incidents. This talk will present some of community concerns around travel on sea ice, the potential impact of increased shipping and the type of ice and weather information that communities would like to see available.

Convenor: Xander Wang

Global warming can intensify the hydrological cycle and lead to more frequent and intense precipitation events around the world. This has become a serious issue for many communities where unprecedented floods due to heavy precipitation have been frequently observed in recent years. How to increase our resilience to floods caused by heavy precipitation under climate change has become one of the major challenges for decision makers, planners, and engineering practitioners. Therefore, this session will be proposed to call for recent research advances and technological development in flood prediction, analysis, and management under climate change. Topics of interest include, but are not limited to, flooding dynamics under heavy precipitation, projections of extreme precipitation events under climate change, real-time and long-term flood prediction, flood risk assessment, flood resilience to climate change, and flood emergency management.

Session: 2010010 Flood risks under climate change L'analyse des risques d'inondation dans le contexte des changements climatiques 08/06/2020 13:00

ID: 10594 Invited session speaker

Anthropocene Flooding: Challenges for Science and Society

Saman WangRazavi [1] , *Laila Balkhi* [2] , *Hayley Carlson* [3] , *Zelalem Tesemma* [4] , *Kasra Keshavarz* [5] , *Patricia Gober* [6] , *Al Pietroniro* [7] , *John Pomeroy* [8] , *Holger Maier* [9] , *Roy Brouwer* [10] , *Howard Wheater* [11]

[1] University of Saskatchewan

[2] University of Saskatchewan
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[4] University of Saskatchewan
[5] University of Saskatchewan
[6] Arizona State University
[7] University of Saskatchewan
[8] University of Saskatchewan
[9] University of Adelaide
[10] University of Waterloo
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Presented by / Présenté par: ***Saman Razavi***
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Current science -policy paradigms for flood risk management inadequately address the profound uncertainties surrounding climate, environment, and societal futures and their complex interactions. We use flood disasters in 2019 as examples to reveal a global narrative about more extreme events, societies being ill prepared for them, and the increasing role of human activity in influencing environmental change. We argue that research and practice must change to embrace transdisciplinary science and public engagement to discover critical future scenarios and inevitable trade -offs in the difficult decision that lie ahead as flood events and impacts of the Anthropocene unfold.

Session: 2010010 Flood risks under climate change L'analyse des risques d'inondation dans le contexte des changements climatiques

08/06/2020 13:30

ID: 10370 Contributed abstract

Evaluation of Summer 2018 Quantitative Precipitation Estimations for the CONtinental United States from Model, Satellite and Radar

Wensong Weng [1] , *Chongxing Fan* [2] , *Peter Taylor* [3] , *Yongsheng Chen* [4] , *Iain Russell* [5]

[1] CRESS, York University
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[3] CRESS, York University
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Presented by / Présenté par: ***Peter Taylor***
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Precipitation is a relatively difficult meteorological quantity to forecast, estimate or measure. In this study, we look at Quantitative Precipitation Forecasts or Estimates (QPF/QPE) by the High-Resolution Rapid Refresh (HRRR) model, the GOES-16 satellite product, the NCEP Stage IV

multisensory data and measured values from the Automated Surface Observing System (ASOS, here after referred to by a more generic term, METAR) network. We base our evaluation on comparisons with station-based observations for the continental USA (CONUS), in the summer of 2018. These data sets are inter -compared, and some simple statistical quantities calculated. Dichotomous forecasts (rain/no rain) are also used to evaluate the estimations or predictions. Results show that compared with the ASOS/METAR observations, the other three data sets over-predict/over-estimate the rainfall and have an overall wet bias. GOES-16 satellite estimation has the largest bias. For light rain, the three QPEs have a wet bias, while for heavy rain, they become dry biased. With a combination of high-resolution radar observation and high-accuracy rain gauge measurements, Stage IV appears to have the best performance in evaluating precipitation, but in our analysis it gives values about 50% higher than METAR measurements. The HRRR data set has more misses, while GOES has more false alarms. Overall, the HRRR data set outperforms that of the GOES. The PRISM daily data are also 50% high relative to METAR measurements and do not correlate as well as Stage IV in our August 2018 data set. Our analysis with these data sets of summer 2018 suggests that further study is needed, and that similar analysis could be undertaken for other years, seasons and regions. More accurate precipitation products may be developed in the future, including from GOES -16, as retrieval algorithms are improved. It will be interesting to see if these lead to better comparisons.

Session: 2010010 Flood risks under climate change L'analyse des risques d'inondation dans le contexte des changements climatiques

08/06/2020 13:45

ID: 10328 Contributed abstract

Evaluation of the high spatiotemporal resolution IMERG V06 precipitation estimates over Canada: implications for flood analysis

saber moazami [1] , *Mohammad Reza Najafi* [2]

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Presented by / Présenté par: ***saber moazami***

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Accurate estimation of precipitation, as the key input variable into hydrological models, is crucial to improve the monitoring and analysis of water resources and provide reliable flood prediction and warning. Considering that ground observations are scarce and commonly include large missing data, the satellite Quantitative Precipitation Estimates (QPEs) can be used to fill the gaps and provide high spatial and temporal resolution estimates of extreme rainfall intensity and frequency, particularly over remote areas and complex terrains. However, because of the inherent uncertainties of remotely sensed precipitation products (partly due to their indirect measurements), evaluations are required before their implementations in different regions. In this study, the most recently released version (V06) of Integrated MultisatEllite Retrievals for Global precipitation measurement (IMERG) Final Run products are analyzed over Canada in hourly temporal and 10 km spatial resolution. We use the quality-controlled rain gauge records as true reference data and apply several performance metrics to evaluate the intensity, temporal variability, and the ability of

IMERG to detect precipitation occurrence. We then investigate the implications of high-resolution precipitation estimates for flood analysis using available insurance claim data. The preliminary results for different study regions suggest that IMERG can represent the amount of precipitation reasonably well particularly over the Prairie provinces and during warm seasons (i.e. fall and summer). Over the western and eastern coastal regions, IMERG tends to overestimate the precipitation value by around 30%. Overall, the study of the hourly performance of IMERG suggests that the product can provide relatively accurate estimates of the precipitation characteristics over diverse climatic conditions in Canada.

Session: 2010010 Flood risks under climate change L'analyse des risques d'inondation dans le contexte des changements climatiques

08/06/2020 14:00

ID: 10456 Contributed abstract

The Impact of Floods on Housing Price: Some Insights Based on a 1998 Flood Event in Laval

Jean Dubé [1] , *Maha AbdelHalim* [2] , *Nicolas Devaux* [3]

[1] Laval University
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Presented by / Présenté par: ***Jean Dubé***
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ABSTRACT
This paper aims to estimate the willingness-to-pay (WTP) for flood as an environmental externality based on a flood event that occurred in Laval in April 1998. The analysis is conducted using information on single-family housing transactions that occurred between 1995 and 2001. The aim of the paper is twofold. Firstly, it investigates the impact of delimitation of flood zones on the estimate obtained through the use of a difference-in-differences (DID) estimator using a hedonic pricing model (HPM) approach. Secondly, it proposes a new and original approach based on a spatial matching methodology that uses a difference-in-differences (SM-DID) estimator to measure the effect of flood based on a proxy of houses that have been actually flooded during a recent event (in spring 2019). Although economic theory suggests a price discount in response to a flood event, there is no consensus in the literature concerning the magnitude or even the direction of such an impact. This research shows that this conclusion is reached mainly because the methodological approach is not precise enough to isolate the houses that have been actually flooded, suggesting that most of the empirical investigation in the literature measure the impact of the "perception of flood risk" instead of the "impact of flood".

Session: 2010010 Flood risks under climate change L'analyse des risques d'inondation dans le contexte des changements

ID: 10564 Contributed abstract

Multivariate statistical analysis of flooding over the Canadian coastal environments

Farshad Jalili Pirani [1] , *Farshad Jalili Pirani* [2]

[1] PhD student
[2] Assistant professor

Presented by / Présenté par: ***Farshad Jalili Pirani***
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The univariate analysis of flooding, i.e. studying each type of flood hazards in isolation, can result in an underestimation of the corresponding impacts. The coincidence of multiple flood generating mechanisms can result in more severe social, economic and environmental consequences compared to the individual occurrence of terrestrial or marine flooding in coastal zones. Canada with the longest coastline (202,080 km) in the world, settles almost 7 million people in its coastal zones, who are prone to flood hazards. In this research, we study flooding over these areas by analyzing four major variables including precipitation, streamflow, total water level and skew surge. To characterize the dependencies between these parameters we use VineCopula, which models multiple conditionally interdependent variables. The return periods of design events are estimated considering the dependencies among variables for all sites. Further, the uncertainty of return periods is characterized using a Bayesian framework. The preliminary results indicate that the estimated return periods decrease when the relationships between different flood generating variables are considered, compared to the estimations obtained based on the traditional independence assumption.

Convenors: David Fissel, Helen Joseph

This interdisciplinary session will present emerging scientific results on the rapidly changing Arctic and northern environment. The physical environment of the Arctic, particularly the Western Arctic within Canada and in Baffin Bay, has changed dramatically over the past 35 years and in particular over the past 15 years. The underlying causes of these changes, in particular in terms of the cryosphere, oceanography, hydrology and meteorology, are being addressed through observational and modeling research. Papers will be presented on the changing Arctic conditions as to their profound effects on larger scale weather, oceanographic and hydrological patterns as well as on the ecosystem, the indigenous peoples of the Arctic, and commercial activities including shipping, The importance of Arctic research and its consequences in looking ahead is very timely and pertinent to informing the public and contributing to public policy issues in this strategically important part of Canada. Scientific papers will be solicited from a wide range of sectors including academia, government research agencies, the private sector, environmental non-governmental, community and First Nations. Papers are sought from research and science activities that is nearing completion, updates on research that is underway and the plans for research and science activities that is planned and just getting underway. This session will seek papers in the following areas: (i) Arctic Meteorology and Climate; (ii) Arctic Oceanography; (iii) the Cryosphere including sea ice, glaciers, terrestrial and marine snowfall and snow accumulation; (iv) interdisciplinary papers on Arctic Ecosystems and (v) policy papers on the Human Dimension of the Changing Arctic.

Session: 2010250 Changing Arctic: Science and Policy Studies - Part 1
L’évolution de l’Arctique : science et politiques - Partie 1

08/06/2020
15:00

ID: 10397 Contributed abstract

The changing ice cover of the Beaufort Sea and the impact of recent extreme events

David Babb [1] , *Ryan Galley* [2] , *Jack Landy* [3] , *David Barber* [4]

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Presented by / Présenté par: ***David Babb***
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The ice cover of the Beaufort Sea has undergone a notable change from a predominantly multiyear ice cover, that was resilient to melt and fostered the distribution of multiyear ice throughout the Arctic, to a primarily seasonal ice cover, that is more susceptible to breakup earlier during spring and melt rapidly during summer. This change began in 1998 but has been accelerating lately and was accentuated by the region becoming completely ice-free during September 2012 and 2016. Sea ice loss is in the region is driven by a combination of dynamic and thermodynamic factors that act across seasonal and interannual scales as year-over-year changes feedback onto themselves and contribute to the continued change in the Beaufort ice cover. A combination of in situ and remotely sensed observations are employed to illuminate and quantify how young, thin and increasingly mobile the Beaufort ice cover has become, increasing its susceptibility to greater summer ice loss. Specifically, increased summer ice loss in recent years were preconditioned by enhanced winter ice export during the preceding winter, making the end-of-winter ice cover thinner and less resilient to spring breakup. Early dynamic breakup created vast areas of open water earlier in spring, initiated the ice albedo feedback loop much earlier than on average and thereby accelerated ice loss throughout summer. Increased summer melt has specifically reduced the likelihood that multiyear ice survives summer through the Beaufort Sea, severing the traditional circulation pattern of multiyear ice within the Beaufort Gyre. Interestingly, as a result of broader changes to the Arctic, the Beaufort Gyre underwent a notable reversal during winter 2017 that may have offered a temporary reprieve from ice loss in the Beaufort Sea. We will end with a discussion of recent work on how this reversal impacted the ice cover.

Session: 2010250 Changing Arctic: Science and Policy Studies - Part 1 L'évolution de l'Arctique : science et politiques - Partie 1 08/06/2020 15:15

ID: 10244 Contributed abstract

The Influence of the wind-driven Mackenzie River Plume on the oceanography of the Canadian Beaufort Sea in late spring and summer

David Fissel [1] , *Keath Borg* [2] , *Matthew Asplin* [3] , *Alexandre Forest* [4] , *Robert Pickart* [5] , *Peigen Lin* [6] , *Donglai Gong* [7] , *Humfrey Melling* [8] , *Francis Wiese* [9] , *Rowenna Gryba* [10]

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[6] Woods Hole Oceanographic Institution
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Presented by / Présenté par: ***David Fissel***
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The Mackenzie River, as the largest river flowing into the Arctic Ocean from North America, has a profound influence on the oceanography of the Beaufort Sea. Unlike all other North American Arctic rivers, discharges occur year-round with peak values during freshet in late May and June, followed by reductions through the summer months, and further reductions in autumn. Low but significant discharges continue from January to early May, much of which accumulates beneath the coastal landfast sea ice on the Mackenzie shelf.

The first extensive study of the distribution of the Mackenzie River plume in the Canadian Beaufort Sea was based on analysis of extensive satellite imagery, surface oceanographic observations and ice charts over the four-year period of 1980 – 1983 (Thomson et al., 1986). This study revealed that the extent and distribution of the plume is primarily determined by the winds, with other contributing factors being the discharge values, ocean currents and the early season sea ice conditions.

Here we provide an updated understanding of the distribution of the Mackenzie River plume and its underlying forcing, based on analyses over the past decade using: satellite imagery of suspended particulate matter (Doxaran et al., 2012) in summer for the years 2008 – 2015; similar satellite imagery along with glider observations in Aug. – Sept. 2016; an extensive array of year-round subsurface mooring data sets from Oct. 2016 – Oct 2018; and satellite imagery data for the late spring and summers of 2017 and 2018.

The results reveal that Mackenzie River plume waters exhibit a very high degree of variability both on seasonal time scales, from freshet through the summer months, and on interannual time scales. Under easterly winds, the Mackenzie River plume extends westward into Alaskan waters over the continental margin with a large offshore displacement, while under westerly winds the plume occupies only the inner portion of the Mackenzie shelf but extends far to the east along the southern coast of Amundsen Gulf.

Session: 2010250 Changing Arctic: Science and Policy Studies - Part 1 L'évolution de l'Arctique : science et politiques - Partie 1 08/06/2020 15:30

ID: 10558 Contributed abstract

Space & time variability of pan-Arctic estimates of internal wave-driven dissipation, mixing, and heat fluxes inferred from the Ice-Tethered Profiler

network

Hayley Dosser [1] , *Melanie Chanona* [2] , *Stephanie Waterman* [3] , *Nicole Shibley* [4] , *Mary-Louise Timmermans* [5]

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Presented by / Présenté par: ***Stephanie Waterman***
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Quantifying mixing rates in the Arctic Ocean is critical to our ability to predict heat flux, freshwater distribution, and circulation. However, turbulence measurements in the Arctic are sparse, and cannot characterize the high spatiotemporal variability typical of ocean mixing. Using year-round temperature and salinity data from Ice-Tethered Profiler (ITP) instruments between 2004 and 2018, we apply a finescale parameterization to obtain pan-Arctic estimates of turbulent dissipation and mixing rates at unprecedented space-time resolution. Building on previous work that used ITP data to identify double-diffusive staircases and analyze the associated convective mixing, we apply the finescale parameterization only where these step-like thermohaline structures are not present and mixing is expected to be internal wave-dominated. We find that the inferred wave-driven dissipation and mixing rates are generally low, but highly variable in both space and time, displaying significant regional differences between the shelves and central basins, as well as a small seasonal cycle. We detect no statistically significant interannual trend in mixing rate estimates over the period examined, with the exception of a small increase in the Canada Basin immediately below the mixed layer. The joint consideration of turbulent dissipation rates and stratification imply varied Arctic Ocean mixing regimes, which are most often not appropriately characterized as isotropic turbulence. Where justified, we infer turbulent heat fluxes out of the Atlantic Water layer that are mostly small, but also exhibit a distinct regional dependence.

Session: 2010250 Changing Arctic: Science and Policy Studies - Part 1 L'évolution de l'Arctique : science et politiques - Partie 1

08/06/2020 15:45

ID: 10555 Contributed abstract

Future Climate Scenarios (to 2070) for northern Baffin Bay and the Pikialasorsuaq (North Water Polynya) region

Paul Myers [1] , *Laura Castro de la Guardia* [2] , *Yiran Xu* [3] , *Liam Buchart* [4] , *Natasha Ridenour* [5] , *Andrew Hamilton* [6]

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Presented by / Présenté par: ***Paul Myers***
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The numerical modelling framework of the Nucleus for the European Modelling of the Ocean (NEMO) is now widely used throughout Canada. Here we use the Arctic and Northern Hemisphere Atlantic (ANHA) regional configuration developed at the University of Alberta to present an overview of modelling capabilities and results for the Pikialasorsuaq (North Water Polynya) region and northern Baffin Bay. This region is one of the most biologically important regions in the Arctic and is important as a traditional hunting/fishing region for the communities in the area, as well as historically allow winter travel between northern Canada and Greenland. To determine how global warming will influence this key region, we drive the ocean and sea-ice model with a 5 member ensemble of bias-corrected historical, RCP4.5 and RCP8.5 CMIP5 model simulations. The climate runs also include projected changes in Greenland melt from a mass balance model and runoff from a hydrological model forced by the same CMIP5 simulations. Experiments are carried out at ¼ resolution from 1981 to 2070. All ensemble members show a strong reduction in sea-ice concentration and thickness in the Pikialasorsuaq. Significant upper-ocean warming also occurs. Salinity changes depend on the size of the estimated future runoff from Greenland, leading to scenarios with more, or less, stratification in the region. Changes in stratification potentially will have large impacts on the productivity in the region.

Session: 2010250 Changing Arctic: Science and Policy Studies - Part 1 L'évolution de l'Arctique : science et politiques - Partie 1

08/06/2020 16:00

ID: 10250 Contributed abstract

The Changing Landscape of Canadian Northern Science Policies and Management

Helen Joseph [1]

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Presented by / Présenté par: ***Helen Joseph***
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This paper will highlight the changing approach to providing scientific knowledge in Canada's Arctic region due in part to new science policies from the Government of Canada and from the Inuit Tapiriit Kanatami (ITK). Examples of this evolving approach to science advice will be presented for two marine initiatives that are developing under these new policies – the Tallurutiup Imanga National Marine Conservation Area and the Pikialasorsuaq (The North

Water Polynya) initiative.

In 2018, the ITK released the National Inuit Strategy on Research (NISR). The ITK is the national representational organization for Inuit in Canada, the majority of whom live in Inuit Nunangat, specifically, the Inuvialuit Settlement Region, Nunavut, Nunavik and Nunatsiavut. The ITK is committed to implementing the NISR in partnership with Inuit representational organizations, governments, and research institutions. The NISR objectives fall within five priority areas: advance Inuit governance in research; enhance the ethical conduct of research; align funding with Inuit research priorities; ensure Inuit access, ownership, and control over data and information; and build capacity in Inuit Nunangat research.

In September 2019, the Government of Canada released Canada's Arctic and Northern Policy Framework. The Framework sets out a long-term, strategic vision that will guide the Government of Canada's activities and investments in the Arctic to 2030 and beyond and will better align Canada's national and international policy objectives with the priorities of Indigenous peoples and Arctic and Northern residents.

Finally, two examples will be presented of how this new policy direction is being implemented in marine management initiatives. One example will be the Tallurutiup Imanga National Marine Conservation Area in the Lancaster Sound region, for which the Inuit Impact and Benefit Agreement was signed in August 2019. Another example of the changing face of research, policy and management interactions will be the Pikialasorsuaq (The North Water Polynya) initiative.

Day 10 - 9 June 2020

Convenors: Paul Kushner, Chris Fletcher, Rebecca Saari, Nathan Gillett, Neil Swart, Kirsten Zickfeld

In order to provide reliable and robust assessment of future impacts of climate change, realistic and quality controlled Earth System Models are required. Each generation of Earth System Models, including components that simulate the physical (atmosphere, hydrosphere, cryosphere), biological (vegetation, carbon cycle and other biogeochemical cycles), and human systems (industrial, agricultural, built environment, and socioeconomic systems), along with the processes that link these components, has provided new insights into the workings of the Earth System and societal interactions with it. These tools have provided our primary means to assess the Earth System's state and fate under historic and projected anthropogenic climate change. Thus, advancing models of the Earth System and its interactions with society is crucial to building resilience to global warming and the related impacts of climate change.

This session encourages contributions dealing with the many facets of Earth System Model development and application, including new modelling results from the Coupled Model Intercomparison Project Phase 6, prediction of global and regional climate on seasonal to centennial timescales, high resolution climate modelling, subgrid scale parameterization development, and model efforts involving full integration of human and natural systems. This session aligns with CMOS 2020 themes related to risks and impacts of climate change (including, potentially, pollution of air, water, and ecosystems), oceans and ice in a changing climate, and Arctic and other cryospheric impacts.

Session: 2010080 Earth System Models As Tools For Societal Resilience - Part 1 Les modèles du système terrestre comme outils de résilience sociétale - Partie 1

09/06/2020
11:00

ID: 10447 Contributed abstract

Surprising new climate change projections from the Canadian Earth System Model 5

Neil Swart [1] , *CanESM5 development team* [2]

[1]
[2]

Presented by / Présenté par: ***Neil Swart***
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The recently completed Canadian Earth System Model version 5 (CanESM5) is a global fully coupled model developed at the Canadian Centre for Climate Modelling and Analysis. The model is primarily used to understand the drivers of historical climate change, and to make century-scale projections of future climate. Over the past year CanESM5 has been used to conduct a wide range of climate related experiments in contribution to the World Climate Research Program's Coupled Model Intercomparison Phase 6 (CMIP6). I will briefly describe CanESM5, and provide an overview of key CMIP6 results, including historical and future climate change, with a focus on Canada. Notably, CanESM5 has a very high Equilibrium Climate Sensitivity, and projects significantly larger future climate warming and climate impacts than it's predecessor CanESM2, which I will briefly explore. As an implication, one would expect CanESM5 to show the carbon budgets available to limit global warming to 1.5 or 2.0 degrees, as required by the Paris Accord, are smaller than those in CanESM2, but we find the opposite to be true. CanESM5 results will appear in the upcoming sixth Assessment Report of the Intergovernmental panel on Climate Change (IPCC), and understanding these changes in the model's behaviour is key to our scientific applications and the provision of advice to climate policy makers and Canadian society.

Session: 2010080 Earth System Models As Tools For Societal Resilience - Part 1 Les modèles du système terrestre comme outils de résilience sociétale - Partie 1

09/06/2020 11:30

ID: 10311 Contributed abstract

Opposite responses of the dry and moist eddy heat transport in the experiments of the polar amplification modeling intercomparison project (PAMIP)

Alexandre Audette [1] , *Robert Fajber* [2] , *Paul Kushner* [3] , *Yutian Wu* [4] , *Yannick Peings* [5] , *Gudrun Magnusdottir* [6] , *Michael Sigmond* [7] , *Lantao Sun* [8]

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Canadian Centre for Climate Modelling and Analysis, Environment and Climate Change Canada.
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Presented by / Présenté par: ***Alexandre Audette***
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Given uncertainty in the processes involved in polar amplification, elucidating the role of poleward heat and moisture transport is crucial. To address this, this study uses the protocol of the Polar Amplification Modeling Intercomparison Project to robustly separate the effects of sea ice loss from ocean surface warming under climate change. A moist isentropic circulation framework accounts for moisture transport, condensation and eddy transport, while connecting the mid-latitudes and the Arctic. It is found that sea ice loss reduces poleward heat transport by warming the returning branch of the moist isentropic circulation at high latitudes, while warming of the ocean surface strengthens the overturning circulation, increasing the total poleward heat transport. Inter-model spread of heat transport into the Arctic reflects the tug-of-war between sea-ice and surface-warming effects.

Session: 2010080 Earth System Models As Tools For Societal Resilience - Part 1 Les modèles du système terrestre comme outils de résilience sociétale - Partie 1

09/06/2020 11:45

ID: 10371 Contributed abstract

Regional drivers of the response of Sahel precipitation to anthropogenic aerosols

Haruki Hirasawa [1] , *Paul Kushner* [2]

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Presented by / Présenté par: ***Haruki Hirasawa***
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Past work using global circulation models (GCMs) has revealed that Anthropogenic Aerosols (AAs) have had significant impacts on the climate during the 20th century. In recent work, we analyzed the response of climate to aerosol forcing in the CESM1 and CanESM2 Large Ensembles of coupled ocean-atmosphere GCM simulations. In these models, AA forcing was the leading driver of a forced decline and recovery of precipitation in the Sahel region of Northern Africa whose timing, though not magnitude, resembled the real-world multi-decadal variability in the region.

To probe the mechanisms underlying the climate response to AA forcing, we decomposed the coupled climate response into the “direct-atmospheric” response directly due to the AA forcing and the subsequent “ocean-mediated” response mediated through AA-forced changes to sea surface temperatures (SST). To do this, we conducted a set of atmosphere-land GCM (AGCM) simulations in CAM5 and CanAM4. We found that the 1970s minus 1950 AA-forced drying was predominantly due to the direct-atmospheric response to changing emissions, while the 2000s

minus 1970s wetting was predominantly an ocean-mediated response. Notably, we found the 1970s minus 1950s ocean-mediated effect was unexpectedly small and the 2000s minus 1970s direct-atmospheric effect caused drying in the Sahel despite declining emissions from Europe to the north.

Thus, to better understand these responses, we study the roles of different regional forcings in the ocean-mediated and direct-atmospheric via a new set of AGCM simulations. For the ocean-mediated response, we apply AA-forced SST anomalies in the Atlantic, Indian, and Pacific oceans separately. We find that the weak 1970s minus 1950s ocean mediated response is caused by the cancellation of wetting due to Pacific anomalies and drying due to Atlantic anomalies. In the 2000s minus 1970s, the recovery is mostly due to Pacific anomalies, with some additional wetting due to Atlantic anomalies. For the direct atmospheric effect, we apply emission changes in Europe and Asia separately. We find that the 2000s minus 1970s drying is due to the remote impact of rising Asian AA emissions, supporting past work on teleconnected responses of African precipitation to Asian AA forcing.

Session: 2010080 Earth System Models As Tools For Societal Resilience - Part 1 Les modèles du système terrestre comme outils de résilience sociétale - Partie 1

09/06/2020 12:00

ID: 10586 Contributed abstract

Constraining human contributions to observed warming since preindustrial

Nathan Gillett [1] , *et al* [2]

[1] Environment and Climate Change Canada
[2]

Presented by / Présenté par: ***Nathan Gillett***
Contact: nathan.gillett@canada.ca

Parties to the Paris Agreement agreed to 'holding the increase in the global average temperature to well below 2°C above pre-industrial levels, and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels'. Monitoring the contributions of human-induced climate forcings to warming to date is key to understanding progress towards the Paris Agreement goals. Using Detection and Attribution Model Intercomparison Project (DAMIP) climate model simulations, and the Regularised Optimal Fingerprinting (ROF) approach, we show that anthropogenic forcings caused 0.9 – 1.3°C of warming in global mean near-surface air temperature in 2010-2019 relative to 1850-1900, compared to an observed warming of 1.1°C, with greenhouse gas and aerosol changes contributing changes of 1.1 – 1.9°C and -0.7 – 0.0°C respectively, and close to zero contribution from natural forcings. These results demonstrate the very substantial human influence on climate to date, and the urgency of action needed to meet the Paris goals.

Session: 2010081 Earth System Models As Tools For Societal Resilience - Part 2 Les modèles du système terrestre comme outils de résilience sociétale - Partie 2

09/06/2020 13:00

ID: 10585 Contributed abstract

Asymmetry in the climate-carbon cycle response to positive and negative CO2 emissions

Kirsten Zickfeld [1] , *Deven Azevedo* [2] , *H. Damon Matthews* [3]

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Presented by / Présenté par: ***Kirsten Zickfeld***
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The majority of emissions scenarios that limit warming to 2°C, and nearly all emission scenarios that do not exceed 1.5°C warming by the year 2100 require negative emissions. Negative emission technologies (NETs) in these scenarios are required to offset emissions from sectors that are difficult or costly to decarbonize and to generate global 'net negative' emissions, allowing to compensate for earlier emissions and to meet temperature targets after overshoot. It is commonly assumed that the carbon cycle and climate response to a negative CO2 emission is equal in magnitude and opposite in sign to the response to an equivalent positive CO2 emission, i.e. that the climate-carbon cycle response is symmetric. This assumption, however, has not been tested for a range of emissions. Here we explore the symmetry in the climate-carbon cycle response by forcing an Earth system model with positive and negative CO2 emission pulses of varying magnitude and applied from different climate states. Our results suggest that an emission of CO2 into the atmosphere is more effective at raising atmospheric CO2 than a CO2 removal is at lowering atmospheric CO2, indicating that the carbon cycle response is asymmetric, particularly for emissions/removals > 100 GtC. The surface air temperature response, on the other hand, is largely symmetric. Our findings suggest that the emission and subsequent removal of a given amount of CO2 would not result in the same atmospheric CO2 concentration as if the emission were avoided. Furthermore, our results imply using simple models used to estimate negative emission requirements may result in underestimating the amount of negative emissions needed to attain a given CO2 concentration target.

Session: 2010081 Earth System Models As Tools For Societal Resilience - Part 2 Les modèles du système terrestre comme outils de résilience sociétale - Partie 2

09/06/2020 13:15

ID: 10432 Contributed abstract

Carbon cycle feedbacks under positive and negative CO2 emissions

Rachel Chimuka [1] , *Claude-Michel Nzotungicimpaye* [2] , *Kirsten Zickfeld* [3]

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[3] Simon Fraser University

Presented by / Présenté par: ***Rachel Chimuka***
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Half of current anthropogenic emissions are absorbed by land and ocean systems. However, this rate of absorption is sensitive to changes in atmospheric CO2 levels and climate. As atmospheric CO2 concentration increases, carbon sinks will sequester more carbon through air-sea exchange and CO2 fertilization, resulting in a negative concentration-carbon cycle feedback. Changes in climate, in response to increasing CO2 concentration, will decrease the efficiency of carbon sinks, resulting in a positive climate-carbon cycle feedback. Research has so far focused on carbon cycle feedbacks under increasing CO2 concentration (positive emissions). Since the majority of scenarios achieving the 2°C climate target require negative emissions technologies, an understanding of carbon cycle feedbacks under decreasing CO2 concentration (negative emissions) is required to produce reliable climate projections. This study uses an Earth system model to investigate carbon cycle feedbacks under positive and negative emissions. To this end, the study analyzes biogeochemically coupled, radiatively coupled and fully coupled climate model simulations with prescribed atmospheric CO2 concentration increasing at 1% per year from preindustrial levels until it quadruples, followed by a 1% per year decline back to preindustrial levels. In response to CO2 changes, the land and ocean initially take up carbon in the negative emissions phase before switching into sources of CO2. In response to changes in climate, the ocean continues to outgas for a century in the negative emissions phase, whereas the land outgases for a shorter time before becoming a sink of CO2. The differences in the behavior of carbon cycle feedbacks under positive and negative emissions are likely largely due climate system inertia: the carbon cycle response under negative emissions is a combination of the response to both negative emissions and the prior positive emissions. This study has implications for the reversibility of climate and CO2 effects on carbon sinks under negative emissions.

Session: 2010081 Earth System Models As Tools For Societal Resilience - Part 2 Les modèles du système terrestre comme outils de résilience sociétale - Partie 2

09/06/2020
13:30

ID: 10452 Contributed abstract

Projected climate impacts along the Canadian Pacific shelf

Amber Holdsworth [1] , *James Christian* [2] , *Youyu Lu* [3]

[1]
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Presented by / Présenté par: ***Amber Holdsworth***
Contact: Amber.Holdsworth@dfo-mpo.gc.ca

A high resolution regional biogeochemical model of the Northeast Pacific Ocean is used to downscale Earth System Model climate projections based on Representative Concentration

Pathways 4.5 and 8.5. Changes in stratification, productivity, acidification, oxygen content, and the distribution of nutrients are examined along the diverse regions of the Canadian Pacific continental shelf. Future (2046--2065) climate simulations show an increasing encroachment of low oxygen and/or low $CaCO_3$ saturation state (acidic) waters onto the continental shelf. Over this time scale, there is very little difference between the moderate mitigation scenario (RCP 4.5) and the highest emissions scenario (RCP 8.5). In addition to saving mean values over each 5 -day averaging period, we also save maximum and minimum values over the same period to investigate extreme values. Both scenarios exhibit more frequent and more extreme states of hypoxia or strongly acidic conditions, particularly in deeper waters of the continental shelf. Temperatures below 7°C account for over 55% of 5-day minimum values in the present climate, but less than 10% in the future, under either scenario.

Session: 2010081 Earth System Models As Tools For Societal Resilience - Part 2 Les modèles du système terrestre comme outils de résilience sociétale - Partie 2

09/06/2020 13:45

ID: 10445 Contributed abstract

A Probabilistic Range of Climatological Normals (1990 - 2020) Derived from Visually Estimated Sea Ice Concentrations in Canadian Ice Service Ice Charts

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Presented by / Présenté par: ***Angela Cheng***
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Sea ice charts are routinely made by national Ice Services to provide accurate and timely information about sea ice conditions. These charts are produced to support navigation in polar regions, to provide information to local communities and to monitor the long-term evolution of sea ice conditions (i.e, climatology). Analysts at the Canadian Ice Service (CIS) predominantly rely on RADARSAT-2 satellite imagery for monitoring sea ice conditions. They analyze areas with similar ice conditions and open water for navigational purposes, then manually delineate them with polygons. The analyst then assigns an estimated concentration value for the polygon using visual segmentation. Every decade, a 30 year climatological normal is calculated using the charts made by analysts. A new climatological normal of sea ice in Canadian waters for 1990 – 2020 will be published by the CIS in 2021.

Despite their subjective nature, charts are used in climatology due to high analyst skill at discriminating ice types that automated algorithms cannot distinguish, and also because the CIS archive provides a long-term archive of observations with high spatial-temporal coverage. However, the level of uncertainty in climatological observations due to analyst subjectivity was previously unquantified.

In this study, we first measured the spread and variability of sea ice concentration estimates by human analysts. Next, we measured the reliability of the charts for end-users. Finally, we applied the findings of our analysis to derive a potential range of climatological normals of sea ice concentrations, their probabilities, and confidence intervals. Thus, we are able to quantify the magnitude of changes in observed sea ice concentration under climate change using the CIS archive while accounting for variations in analyst subjectivity.

Session: 2010081 Earth System Models As Tools For Societal Resilience - Part 2 Les modèles du système terrestre comme outils de résilience sociétale - Partie 2

09/06/2020 14:00

ID: 10357 Contributed abstract

Characterizing uncertainties on Arctic snow-on-sea-ice for climate analysis

Alex Cabaj [1] , *Paul Kushner* [2] , *Alek Petty* [3] , *Christopher Fletcher* [4] , *Stephen Howell* [5]

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Presented by / Présenté par: ***Alex Cabaj***
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Snow on Arctic sea ice plays multiple roles in several sea ice-climate feedbacks. For example, the high albedo of snow can mitigate sea ice melt, but conversely, the insulating properties of snow can inhibit sea ice growth. Furthermore, snow contributes to uncertainties in retrievals of sea ice thickness from satellite altimetry measurements. In situ measurements of snow depth on Arctic sea ice are sparse, so snow-on-sea-ice models are often used to obtain basin-wide snow depth estimates. However, these models often require snowfall input from reanalysis products, which are likewise difficult to validate due to the lack of in situ snowfall measurements over the Arctic.

In the absence of in situ snowfall measurements, satellite snowfall rate observations can be used to constrain Arctic snowfall. The CloudSat satellite provides the most extensive high-latitude snowfall rate observation dataset currently available. CloudSat's 94-GHz Cloud Profiling Radar instrument measures vertical radar reflectivity profiles, from which

snowfall rates can be retrieved.

In this work, reanalysis snowfall rates are calibrated to CloudSat observations over the Arctic Ocean, and used as input for the NASA Eulerian Snow On Sea Ice Model (NESOSIM), which produces basin-wide estimates of snow depth on sea ice. These snow depths are then used in the retrieval of sea ice thickness from ICESat-2 satellite sea ice altimetry measurements. Thus, this calibration provides an observational constraint on both model -derived snow depths, and sea ice thickness estimates. In light of this calibration, we characterize uncertainties in retrieved sea ice thickness and model-based snow depth estimates resulting from uncertainties in snowfall rate input.

Day 11 - 15 June 2020

Convenor: Xuebin Zhang, Jeremy Fyke, Francis Zwiers

Much of Canada's infrastructure is designed to function under the anticipated weather and climate condition during their life span. It is thus very important to know at the time of design the future weather and climate condition and their extremes in particular. Provision of such information that reflects future climate at the local scale and that is readily available for engineering applications is a challenge. This is because a set of simple values are often desired or required for practical application on one hand, while there is large uncertainty inherent in the regional and local scale climate projection on the other hand. Uncertainties in climate projections exist with respect to future socio-economic development and mitigation efforts, in our understanding of the climate system and our capability in simulating it, and due to the natural internal variability of the climate system. This session attempts to facilitate two-way communication between climate research and the infrastructure sector, on the climate information needs and on the means of meeting those needs related to code/standard development and environmental assessment. To this end, we invite presentations on the construction of climate change information for resilient infrastructure. Papers on information needs for climate resilient infrastructure, on the process of establishing codes and standards, and on the development of future projections of weather and climate extremes relevant to infrastructure adaptation, are particularly welcome.

Session: 2010210 Climate Change information supporting resilient infrastructure - Part 1 L'information sur les changements climatiques au service d'une infrastructure résiliente - Partie 1

15/06/2020 11:00

ID: 10266 Contributed abstract

Long period return-level estimates of extreme precipitation

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Presented by / Présenté par: ***Francis Zwiers***
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Statistical extreme value theory (EVT) is a fundamental tool for characterizing climate extremes and understanding whether they are changing over time. Most operational frequency and intensity estimates are obtained by using EVT to analyze time series of annual maxima, for example, of short duration precipitation accumulations or some aspect of wind speed. A key implicit assumption in the application of EVT is “max- stability”, i.e., that the statistical behaviour of annual maxima is predictive of maxima calculated over multi- decadal or longer intervals. This assumption cannot be tested using available observational records, and it is rarely discussed in studies of extremes. Here we use a recent large ensemble simulation to assess whether max-stability holds for annual maxima of extreme precipitation. We find that annual maxima tend not to be max-stable in the model-simulated climate. We explore the implications of the lack of max-stability on the estimation of very long period return levels, and discuss reasons why the annual maxima of precipitation extremes may not be max-stable. We also demonstrate a possible solution that is based on an alternative statistical approach that incorporates additional process based information into the analysis. While our study focuses on precipitation simulated by a regional climate model, our findings have serious implications for the estimation of high return levels of many climate and weather elements from models and observations that may potentially impact engineering practice.

Session: 2010210 Climate Change information supporting resilient infrastructure - Part 1 L’information sur les changements climatiques au service d’une infrastructure résiliente - Partie 1

15/06/2020 11:30

ID: 10569 Contributed abstract

Development of Requirements and Guidelines for Flood-Resistant Buildings

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Presented by / Présenté par: ***Muhammad Naveed Khaliq***
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The National Research Council Canada (NRC) is leading the Climate-Resilient Buildings and Core Public Infrastructure (CPI) project, with funding from the Federal Government of Canada through Infrastructure Canada to develop decision-support tools, including codes, guides and models, to enhance the resilience of Canada’s buildings and CPI against climate change and extreme weather events. Improving the performance of buildings exposed to flooding is an important initiative of the CRB-CPI project in order to alleviate the rising costs associated with recurrent flood-related damages. There is also a likelihood that the frequency and intensity of future floods, impacted by climate change, may further push these costs upward. In collaboration with national and international partners, the NRC is developing requirements and guidelines for the design of flood-resistant buildings, as well as guidelines for improving the flood resistance of existing buildings. The required knowledge and data on flood loading parameters is being developed through a number of flood modelling and mapping case studies, selected from riverine, coastal and urban environments. This

presentation will discuss various outcomes that have been realized, especially the flood loading parameters, to support the flood-resistant buildings initiative.

Session: 2010210 Climate Change information supporting resilient infrastructure - Part 1 L'information sur les changements climatiques au service d'une infrastructure résiliente - Partie 1

15/06/2020 11:45

ID: 10407 Contributed abstract

A Computational Wind Engineering (CWE) framework for studying climate change-based wind loads on high-rise buildings in dense urban areas

Alfonso Teran [1] , *Jie Song* [2] , *Hamidreza Naderian* [3] , *Zhang Xuebin* [4] , *Jamil Mardukhi* [5] , *Paul Kushner* [6] , *Oya Mercan* [7]

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Presented by / Présenté par: ***Alfonso Teran***
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Structures in the built environment that are safe and serviceable under wind loading within current climate conditions may experience problems in the coming decades as wind load characteristics get affected by rapidly changing climate. Given the great uncertainty in prediction of future wind environment conditions, there is a need for a formulation of flexible adaptation strategies to mitigate the effects of climate change in megacities, which requires a collaborative effort from a variety of disciplines. The present work proposes a multi-disciplinary framework combining climate science, wind engineering, and structural engineering using computational fluid dynamics to investigate and address the effects of climate change and the associated wind load effects on the built environment. High-performance computing techniques and resources are an essential part of the proposed framework within which the CFD simulations are performed. The outcome of this cross-disciplinary infrastructure seeks to translate the range of predicted effects of climate change into actionable knowledge useful in the area of urban building design. Using the downscaled wind speed data from global climate models we will calculate the future design wind speed for Toronto and perform CFD simulations of a specific building to compute the forces acting on the building and evaluate its dynamic response. In the long term, this will deliver sustainability and resiliency-focused design, as well as retrofit recommendations for practitioners and decision-makers to provide a direct benefit to the residents of large cities.

ID: 10293 Contributed abstract

Developing guidance on the development, interpretation, and use of IDF information

Paul Steenhof [1]

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Presented by / Présenté par: ***Paul Steenhof***
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It is widely recognized that extreme precipitation events can have significant impacts on built infrastructure. In Canada, such events in fact have led to some of the highest economic losses relative to any other type of weather peril. One of the most important elements that can dictate the eventual effects of a heavy precipitation event on built infrastructure is the adequacy of the storm water systems designed, engineered and constructed to manage the large volumes of water commonly associated with such weather events. In this respect, infrastructure practitioners commonly use IDF information to inform the structural details of storm water infrastructure. IDF information, in brief, describes the frequency (in terms of probability of occurrence) of extreme rainfall events of various rates and duration. IDF information specifically provides key inputs into formula used in determining the performance characteristics of built storm water infrastructure.

This presentation reviews recent work to update CSA Plus 4013 (2nd Ed. Pub. 2012) - Technical Guide: Development, Interpretation and Use of Rainfall Intensity-Duration-Frequency (IDF) Information: Guideline for Canadian Water Resources Practitioners, so that this document reflects the latest scientific understanding of climate change and how to incorporate climate change into the formulation and application of IDF information.

The general purpose and driver in the development of this guidance document was to encapsulate the experience and expertise of climate scientists, hydrologists and infrastructure practitioners in the generation and use of IDF information in Canada as it was seen that there was an increase the demand for IDF information and because there was a broadening number (and range) of entities providing this information.

Also discussed are further possibilities to advance the current version of CSA PLUS 4013 as well as ideas on the development of complementary guidance or standards.

ID: 10363 Contributed abstract

Transferring climate information to the engineering community: actual initiatives, challenges and opportunities

Alain Mailhot [1] , *François Groux* [2]

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Presented by / Présenté par: ***Alain Mailhot***
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The engineering community faces many challenges when designing long-term infrastructures. For instance, when designing hydraulic infrastructures (e.g., bridges, culverts, dams, water intake, transport infrastructures) they often have to use climatic information (e.g., Intensity-Duration-Curves – IDF curves) from distant station, therefore raising the issue of the representativeness of this information at the design site. The issue of climate change is also crucial when designing infrastructures with expected service life that will last many decades. Without specific guidelines from the scientific community they must often rely on readily information they can quickly gathered.

This presentation will be divided into two parts. The first part will present different initiatives over the past years to provide information about the impact of climate change on extreme precipitation to different Quebec agencies, municipalities and ministries (e.g., Ministère des Transports, Quebec City). Examples as to how this information is actually used by the Quebec engineering community will also be provided. Actual initiatives in order to revise this information will finally be presented.

The second part of the presentation will discuss the actual needs of the engineering community, both in term of defining more reliable datasets characterizing the historical climate, and guidelines as to how the climate change should be taken into consideration in engineering practice. The importance of building bridges between the scientific and engineering communities will be stressed as well as the responsibility of the scientific community to organize a collective response to these demands. These are the conditions under which trustworthy and relevant information could be validated and transferred from the scientific to the engineering community.

Session: 2010211 Climate Change information supporting resilient infrastructure - Part 2 L'information sur les changements climatiques au service d'une infrastructure résiliente - Partie 2 — 15/06/2020 13:00

ID: 10446 Contributed abstract

Information on climate design values in Canada for enhanced resilience to future climate conditions

Alex Cannon [1] , *Xuebin Zhang* [2] , *Dae Il Jeong* [3]

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Presented by / Présenté par: ***Alex Cannon***
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Many aspects of Canada's infrastructure will be directly affected by climate change. Information about impacts of climate change on climatic design data, such as wind loads, snow loads, extreme temperature, and extreme precipitation, cannot be reliably obtained by analysis of historical data and extrapolation of observed trends. Instead, quantitative guidance on future climate change relevant to Canada's Buildings and Core Public Infrastructure (B&CPI) requires a combination of physical process understanding and analysis of climate model simulations. The credibility, and hence uncertainty, of climate model outputs differs for each climatic design variable and must therefore be accompanied by an assessment of model limitations and an evaluation of uncertainty. Environment and Climate Change Canada's Climate Research Division recently completed a project with National Research Council of Canada and partners that assessed relevant climate science - - and developed and communicated future climate projections and their uncertainty - - relevant to B&CPI in support of the Pan Canadian Framework on Clean Growth and Climate Change and the Green Infrastructure Program objectives of the Canadian government. This talk will summarize the scope of the project, the dialogue between the infrastructure design and climate science communities that guided the process, and key findings communicated in the final report.

Session: 2010211 Climate Change information supporting resilient infrastructure - Part 2 L'information sur les changements climatiques au service d'une infrastructure résiliente - Partie 2 — 15/06/2020 13:30

ID: 10476 Contributed abstract

Site specific ensemble simulation of permafrost change

Stephan Gruber [1] , *Bin Cao* [2]

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Presented by / Présenté par: ***Stephan Gruber***
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The ability to characterize likely future trajectories and current rates of permafrost thaw for specific locations and conditions is import for supporting the design of resilient Arctic infrastructure. It requires atmospheric data as a temporal driver, subsurface information as a determinant of impacts, as well as models and reference data representing the relevant

processes and phenomena. This presentation shows insight from a cluster of instrumented sites in the tundra near Lac de Gras, N.W.T. as well as progress in simulating ground temperature with a model driven by multiple reanalyses. Simulation results reproduce seasonal cycles and lateral variation between terrain types well. Ensemble means using multiple reanalyses (ERA5, JRA-55, MERRA2 and ERA-Interim) often yielded better accuracy than individual simulations and ensemble ranges additionally provide indications of uncertainty arising from uncertain input. The toolset for obtaining reanalysis time series is the critical enabler for running physics -based permafrost models in remote and data sparse locations. Comparing their results with large ensembles of ground temperature data differentiated by terrain type allows evaluating how well the changes that cause permafrost thaw are represented in the simulation stack employed.

not presented

Session: 2010211 Climate Change information supporting resilient infrastructure - Part 2 L'information sur les changements climatiques au service d'une infrastructure résiliente - Partie 2 15/06/2020 13:45

ID: 10354 Contributed abstract

Future precipitation caused landslide hazard in British Columbia

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Presented by / Présenté par: ***Stephen Sobie***
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Landslide hazards in British Columbia are mainly caused by precipitation and can result in significant damage and fatalities. Anthropogenic climate change is expected to increase precipitation frequency and intensity in the Winter, Spring and Fall in British Columbia (BC), potentially resulting in increased frequency of landslide hazard. Quantifying the effect of changing precipitation on future landslide hazard across the varying topographic and climatic conditions in BC requires detailed projections of future precipitation. Here, the operational Landslide Hazard Assessment for Situation Awareness (LHASA) model is used with high -resolution, statistically downscaled precipitation to generate detailed simulations of landslide hazard in BC over the 21st century. Using the LHASA model with precipitation projections from 12 downscaled global climate models reveals future landslide hazard frequency is expected to increase by from 11 to 14 events per year on average by the 2050s for the province as a whole. Areas of the province currently with the greatest landslide hazard, including the west coast and northern Rocky Mountains, are expected to see up to 12 additional events per year. Most of the increased hazard event frequency occurs during Winter and Fall, reflecting those seasons with the largest projected precipitation increases. Risk assessments for regions and infrastructure in

British Columbia vulnerable to landslides will need to account for increasing hazard due to climate change altered precipitation.

Session: 2010211 Climate Change information supporting resilient infrastructure - Part 2 L'information sur les changements climatiques au service d'une infrastructure résiliente - Partie 2 15/06/2020 14:00

ID: 10315 Contributed abstract

Predicting Future Storm Surges and Waves in British Columbia Coastal Waters to Support Climate Risk Assessment and Coastal Infrastructure Adaptation

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Presented by / Présenté par: ***Enda Murphy***
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Storm surges and waves are key climate-driven parameters affecting the design and operation of ports and other transportation infrastructure on the coast. Reliable predictions of future storm surges and wave conditions are not yet available for the British Columbia (B.C.) coast, and this data gap hinders effective climate risk assessment, planning and adaptation. Transport Canada's Transport Asset Risk Assessment (TARA) initiative, through its mandate to enhance the resilience of federally-owned transportation assets by giving decision-makers the information they need to make informed decisions, is supporting research to address this gap. A set of regional numerical models have been developed to simulate storm surges and wave conditions in B.C.'s marine waters. The models are forced by wind and atmospheric pressure data; and calibrated and validated using available wave buoy and tide gauge measurements. The validated models are being used to simulate, over multi-decadal timescales, historical and future storm surges and near-coast wave conditions for several climate change scenarios. A comparison of the historical and future simulation results reveals the potential impacts of climate change on extreme water levels and wave conditions. The resulting database will be disseminated to stakeholders via an interactive visualization tool, which will be scalable and transplantable to other regions and infrastructure / asset types. The new database and visualization tool will enable climate risk assessments to be undertaken for transportation assets, coastal infrastructure and communities located on or near the B.C. coast. Application of the tool for climate risk assessment and adaptation planning purposes will be demonstrated through case studies for several federally-owned transportation assets on the B.C. coast.

Session: 2010211 Climate Change information supporting resilient infrastructure - Part 2 L'information sur les changements climatiques au service d'une infrastructure résiliente - Partie 2 — 15/06/2020 14:15

ID: 10304 Contributed abstract

Climate Change Impact on Sump and Permafrost in the Inuvialuit Settlement Region (ISR), Northwest Territories

Xin Qiu [1] , *Tod Collard* [2] , *Maria Kudienko* [3] , *Fuquan Yang* [4]

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Presented by / Présenté par: ***Xin Qiu***
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The potential for a degrading environmental condition of drilling waste sumps is of high concern to the Inuvialuit in the Inuvialuit Settlement Region (ISR). The potential degradation and failure of those sumps could result in a discharge of contaminated materials in areas throughout the ISR and Mackenzie Delta region. A study has been conducted for drilling waste sump inventory and climate change assessment to address the concern of the Inuvialuit people. This study evaluates the air/ground temperatures and precipitation in the region and the predicted changes of these climatic parameters. The study estimates the warming effect on the long-term stability of the permafrost and the potential impact to the sump sites. Historical data was used to extrapolate future climate in the region and analyze how this climate change may impact drilling waste buried in the permafrost in the study area. Air and ground temperatures and precipitation trends were analyzed for the observation period 1979-2018, and near future climate downscaling was studied by nonparametric Mann-Kendall test (M-K test) and Sen's slope methods. Climate variables included: precipitation, air/ground temperature at various depths. Risk rankings are based on available sump toxicity (mud additives) and stability data (past field inspections and indigenous people interviews), proximity to receptors, and future climate considerations. In addition, mitigation measures will be developed to reduce risks and environmental impacts related to deteriorating permafrost.

Session: 2010212 Climate Change information supporting resilient infrastructure - Part 3 L'information sur les changements climatiques au service d'une infrastructure résiliente - Partie 3 — 15/06/2020 15:00

ID: 10400 Contributed abstract

Incorporation of Climate Change Into Stormwater Management Infrastructure Design in the Face of Deep Uncertainty

Elise Pare [1]

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Presented by / Présenté par: ***Elise Pare***
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A variety of approaches have been taken to incorporate climate change into IDF curves to support the engineering design community, but typically focus on a singular 'climate change factor' which can have some significant challenges including data limitations, climate projection uncertainty, and application to required design criteria, especially related to sub-hourly rain events.
We need to plan for an uncertain future. However, over-designed infrastructure will lead to increased capital costs, or conversely to under-designed infrastructure could lead to property damage, economic impact and even risk to life.

WSP incorporated current international best practices in climate change risk management and applied that to a local context for two rural, mountainous communities in the Elk Valley of British Columbia with different micro-climates. A process was identified to assign appropriate levels of resilience to higher risk scenarios. As part of this process, assessment criteria were developed which the communities can use to select adaptation measures to address design scenarios.

A risk management-based decision-making guideline was developed on how the projected rainfall curves should be applied in various design situations in the face of uncertainty due to climate change to facilitate practical decision making and proportionate actions. The process incorporates design life of infrastructure, a consequence analysis, determination of adaptive management potential and performing a sensitivity analysis on climate projection choice.

This presentation will focus on the need for design decisions to be made now with imperfect information and how the engineering designer can move forward with a documented risk management-based process to incorporate climate change projections into current design.

Session: 2010212 Climate Change information supporting resilient infrastructure - Part 3
L'information sur les changements climatiques au service d'une infrastructure résiliente - Partie 3
15/06/2020 15:15

ID: 10350 Contributed abstract

A new methodology for estimating historical snow loads for

infrastructure design in Canada

Charles Curry [1] , *Yaqiong Wang* [2] , *Charlotte Ballantyne* [3] , *Francis Zwiers* [4] , *Faron Anslow* [5]

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Presented by / Présenté par: ***Charles Curry***
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A systematic reevaluation of ground snow loads over Canada has been performed using a methodology that improves upon previous National Building Code of Canada (NBCC) updates. Two independent sources of historical ground snow data were employed: the MSC (Meteorological Service of Canada) data set, consisting of daily snow depth (SD) measurements for 4412 stations, and the Manual Snow Survey data set, comprising snow water equivalent (SWE) data collected from 3320 locations, none exactly coincident with a MSC station. These extensive data along with a geographic snow climate classification scheme were used to develop power-law relationships between annual maximum SD and SWE over Canada, allowing the derivation of annual maximum SWE time series at each MSC station. After extensive quality control, an extreme value analysis was then applied to these time series to estimate the 50-year return level of annual maximum SWE and the corresponding snow load at over 500 MSC stations across Canada. Subsequent analysis of daily rainfall data resulted in the estimation of the 50-year return level of rain-on-snow loads at the same locations. A comparison of these results with those from the most recent NBCC (2015) exercise, which shows some systemic differences, will be presented. For example, although the medians are similar, the range of snow loads across Canada (0.4-20 kPa) is about twice that obtained in NBCC (2015).

Session: 2010212 Climate Change information supporting resilient infrastructure - Part 3
L'information sur les changements climatiques au service d'une infrastructure résiliente - Partie 3

15/06/2020 15:30

ID: 10341 Contributed abstract

Abrupt changes across the Arctic permafrost region endanger northern development

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Presented by / Présenté par: ***Bernardo Teufel***
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Extensive degradation of near-surface permafrost is projected during the 21st century, which will have detrimental effects on northern communities, ecosystems and engineering systems. This degradation will expectedly have consequences for many processes, which most previous modelling studies suggested would occur gradually. Here, we project that soil moisture will decrease abruptly (within a few months) in response to permafrost degradation over large areas of the present-day permafrost region, based on analysis of transient climate change simulations performed using a state-of-the-art regional climate model. This regime shift is reflected in abrupt increases in summer near -surface temperature and convective precipitation, and decreases in relative humidity and surface runoff. Of particular relevance to northern systems are changes to the bearing capacity of the soil due to increased drainage, increases in the potential for intense rainfall events and increases in lightning frequency, which combined with increases in forest fuel combustibility are projected to abruptly and substantially increase the severity of wildfires, which constitute one of the greatest risks to northern ecosystems, communities and infrastructure. The fact that these changes are projected to occur abruptly further increases the challenges associated with climate change adaptation and potential retrofitting measures.

Session: 2010212 Climate Change information supporting resilient infrastructure - Part 3
L'information sur les changements climatiques au service d'une infrastructure résiliente - Partie 3

15/06/2020 15:45

ID: 10247 Contributed abstract

Strategies for Integrating Climate Projection Information into Infrastructure Design

Jeremy Fyke [1] , *Alex Cannon* [2] , *Don Kennedy* [3]

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Presented by / Présenté par: ***Jeremy Fyke***
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Information from climate model-based climate change projections is now being integrated into very consequential Canadian infrastructure design decisions at an accelerating pace. Uptake of climate projection information into infrastructure design is motivated by the need of the design engineering community to satisfy emerging federal-level codes, standards, guidance and regulations targeted at increasing national climate change resilience. It is also motivated by a desire of infrastructure designers, owners and operators to reduce risk of (and liability for) infrastructure damage stemming from impacts attributable to climate change.

Because of these trends, demands for clear translation of climate projection information into risk-based engineering design is increasing. However, bridging the gap between climate science and engineering design involves substantial technical and communications challenges. For example, robustly integrating simulated information derived from ensembles of climate model runs into 'shop-floor' design thresholds must respect inherent climate model, downscaling, and statistical limitations - while also conveying uncertain climate change information in a manner that meets specific engineering design needs.

In this presentation, we will describe several large-scale projects in which climate projections were (or are being) considered in the context of infrastructure design. Based on lessons learned from these projects, we will outline what we think are several key strategies for effectively integrating climate change into infrastructure engineering projects. We will highlight the importance of:

• Effectively communicating climate science and climate modelling fundamentals;

• Clearly grasping engineering goals, guidelines, and constraints;

• Integrating climate change projections into project risk assessments; and

• Adapting to rapidly evolving legal, regulatory, financial, and professional standards;

in bridging the gap between climate science and national infrastructure planning.

ID: 10324 Contributed abstract

Climate Projections for Multiple Sectors in Ottawa

Lea Braschi [1] , *Lindsay Wilcott* [2] , *Vincent Leys* [3] , *Esther Gomes* [4] , *Aline Kaji* [5]

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Presented by / Présenté par: ***Lea Braschi***
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Cities rely on the availability of robust and reliable projections in order to prioritize assets and adapt to climate change. Climate data is increasingly available through various portals and studies, but the range of methodologies and products can make it challenging for policy makers to decide which to use. Furthermore, indices are sometimes appropriate for climate studies but not impact and risk assessments.

A regional approach was adopted for the City of Ottawa/National Capital Region, combining and contrasting model outputs obtained from various partners. Targeted impact-based indices were computed for use in risk and vulnerability assessments across diverse sectors (water services; health and safety; buildings and heritage; natural assets tourism and recreation; and transportation). Projections were summarized in a publicly-accessible report and infographics. This presentation will discuss considerations for the development of reliable and robust climate projections based on current advances and limitations in climate science, including challenges with single-station bias-correction, and lessons learnt from using gridded, statistically-downscaled ensemble projections for precipitation extremes.